Perceptions of cultural ecosystem services of tree-based green infrastructure: A focus group participatory mapping in Zagreb, Croatia

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Abstract

Urban green infrastructure provides city dwellers numerous benefits. Among them, cultural ecosystem services (CES) are distinguished by being easily perceived and essential for people and their well-being. However, not all CES are equally easy to perceive, resulting with some of the CES categories being weakly explored. Research on CES also rarely considers elements of urban green infrastructure other than parks and forests. Therefore, there is a lack of research on different components of urban green infrastructure, especially tree-based, perceived in relation to CES. This paper presents the results of focus group participatory mapping implemented with citizens in the city districts of Zagreb on the perception of five selected CES categories in various types of urban green infrastructure. Our results show that participants perceived 13 different types of tree-based urban green infrastructure as providers of CES. We also distinguish patterns in the perception of CES categories and their connection with types of tree-based urban green infrastructure. Tree lines are perceived as providers of aesthetical experiences. Furthermore, forests and park forests are perceived in relation to place attachment and recreational activities, while parks are versatile and provide all explored CES. Other types that emerged as important were greenways, greenery around residential buildings and educational institutions, which provokes rethinking of a careful planning of the entire repertoire of urban green infrastructure.

Keywords: aesthetics; correspondence analysis; cultural identity; educational services; place attachment; recreation

1. Introduction

Urban green spaces are an important element in cities and contribute to improving the health and well-being of city residents. Urban green infrastructure (UGI) is planned and managed to provide various ecosystem services. It also helps in mitigating environmental issues and improve the quality of life in cities (Haase et al., 2014). When addressing ecosystem services provided by UGI, monetary and non-monetary valuation methods of UGI benefits may be applied, but they do not directly account for human needs or preferences (ibid.). However, stakeholder involvement is a valuable addition to standard data gathering methods by bearing local knowledge and enhancing the assessment results (Fagerholm et al., 2012). It is especially important when assessing cultural ecosystem services (CES), defined as 'nonmaterial benefits people obtain from ecosystems' (MEA, 2005), whose manifestation is significantly influenced by people's perception. CES are of great importance for people living in cities, since they are one of the prominent contributors to the well-being (Plieninger et al., 2013). However, they are difficult to assess and value (Small et al., 2017).

There is growing scientific interest in CES (Cheng et al., 2019). CES have been shown to be essential for citizens and are constantly highly ranked in perceived importance in comparison to other ecosystem services (Beichler, 2015). Still, they are not equally perceived among people, e.g., aesthetics and recreation are more often and more easily perceived categories, while education is a less perceived category of CES in urban areas (Beichler, 2015). Also, people usually put greater general importance on recreational services in cities (Dou et al., 2017; Rall et al., 2017), while studies addressing multiple CES at the same time are still lacking (Cheng et al., 2019).

UGI is the main provider of CES in urban areas. In that regard, parks and urban forests are better explored in relation to CES provision (Bertram and Rehdanz, 2015; Hegetschweiler et al., 2017; Korpilo et al., 2018; Zwierzchowska et al., 2018; Baumeister et al., 2020). In general, parks are usually perceived as providers of passive or low intensity recreation, social opportunities and cultural heritage values across different cities in Europe (Bertram and Rehdanz, 2015; Rall et al., 2017; Zwierzchowska et al., 2018; Vierikko et al., 2020). Urban forests are perceived as providers of recreational opportunities, aesthetic and cultural heritage values, with strong reminiscent character (Arnberger, 2006; Baumeister et al., 2020; Kičić et al., 2020). Biodiversity, education and experiences in nature, as well as aesthetics and spirituality are found as the emerging characteristics perceived in forests (Plieninger et al., 2013; Rall et al., 2017). Restoration, heritage values, sentient and their quiet character are connected with the perception of cemeteries as unique green spaces in cities (Nordh et al., 2017; Pietrzyk-Kaszyńska et al., 2017). There is a gap in literature reflected in the scarcity of papers dealing with the connection between CES and other types of UGI, especially those which are tree-based such as tree lines, greenery around educational facilities or neighbourhood greenery (but see Rall et al., 2017; Krajter Ostoić et al., 2020a). Knowledge about the perception and use of other UGI types exists; however, it does not always employ the CES framework, e.g., in the case of urban stream corridors (Scott Shafer et al., 2013; Garcia et al., 2017), neighbourhood greenery (Säumel et al., 2021), and the perception of trees in urban areas (Graça et al., 2018; Fernandes et al., 2019). Therefore, it would be beneficial for scientific literature and local management to identify comprehensively how the perception and use of CES are related to various types of tree-based UGI. Comprehensive overview of perception and use of different types of tree-based UGI allows for tree and green space management practices to be refined and enhanced contributing to increased quality of green areas and subsequently citizens' wellbeing.

Since CES are essentially intangible, revealing provision locations is a vital part of their mainstreaming into spatial planning practices (Ives et al., 2017). It is important to consider the perception and use of those at the receiving end of ecosystem benefits, i.e. users (Brown and Fagerholm, 2015). One of the useful approaches to collect information on perception and its spatial distribution is participatory mapping. It can help facilitate the manifestation of intangible ecosystem services such as CES in a visible form (Hernández-Morcillo et al., 2013). It can be implemented by using different methods such as focus groups (Lowery and Morse, 2013), group mapping (Beichler, 2015), face-to-face interviews (Plieninger et al., 2013) and small group interviews (Xu et al., 2020) to collect spatial data to identify a range of values and land use issues (Brown et al., 2014a).

Therefore, the goals of this paper are: 1) To quantify and explore the perception of five CES expressed by residents of city districts in the city of Zagreb utilizing focus group participatory mapping, 2) To explore the relationship between the perception of five CES and tree-based UGI throughout Zagreb's city districts.

The study area for this research is the City of Zagreb in Croatia, which can be considered as the postsocialist city. Indeed, Zagreb is facing similar problems to those of postsocialist cities in Central and Eastern Europe (Kronenberg et al., 2020). Therefore, this paper contributes to a better understanding of the perception of CES in a postsocialist cultural context. Recent literature review on urban forest and urban green space research in Croatia and Slovenia demonstrated the existence of public perception studies, although sparse (Krajter Ostoić et al., 2020b). While most of those in Croatia were conducted in Zagreb, there is a shortage of studies dealing simultaneously with the perception of multiple sites and different types of green spaces. However, recently, the relation between the perception of CES and tree-based green spaces in Zagreb was presented based on a qualitative analysis of focus group transcripts (Krajter Ostoić et al., 2020a).

We have used quantitative analysis of spatial markers collected with participatory mapping during focus groups to explore and quantify the connections between tree-based UGI and perceived CES in city districts in Zagreb. In doing so, we build on previous research on green spaces in Zagreb together with other research on CES and UGI across Europe and expect to achieve comparable novel results on the emerging perception patterns of CES and their manifestation in different tree-based UGI in Zagreb.

2. Material and methods

2.1. Study area

The city of Zagreb, a Croatian capital, is located in the northwest part of the country. Zagreb is the largest city in Croatia as well as the economic and political centre. It extends over of 641.32 km^2 with total population of 804,507 citizens (estimated for 2018) and an average population density of 1,254 inhabitants per km^2 (Statistical Yearbook of the City of Zagreb (SYCZ), 2019). The city is divided into 17 city districts and 218 community boards that represent a form of local self-government (Fig. 1). City districts vary in size and population density. Moreover, they differ based on terrain configuration, the proportion of built-up areas, UGI types, and spatial distribution.

Forests are the most prominent type of UGI in Zagreb, is covering approx. 20,000 ha (differentiated by ownership into state-owned and privately-owned in almost equal shares). In addition to forests, there are other types of UGI in Zagreb (e.g., 59.2 ha of parks, 243 km of tree-lined roads, and 9,492.28 ha of protected areas in various categories) (SYCZ, 2019). The aforementioned UGI is under the city's funding and management, except for forests and park forests which are managed by a public forest management company (Croatian Forests Ltd.). Management of park forests is co-financed by the city's annual budget and the city department determines management and controlling of the conducted work and its quality. (Krajter Ostoić, 2013).

Due to the diversity of UGI types in Zagreb, here were describe only some of the bigger natural areas important for the study area context. Out of 9,492.28 ha of protected areas, around 8,500 ha belongs to Nature Park Medvednica located at the Medvednica mountain in the north from the city and partly located within the city's borders. Park forests are forest areas managed primarily for aesthetic and recreational purposes (Matić, 2010). Through Zagreb also runs the Sava River, (28.7 km in length), along whose banks there is a greenway that is a highly visited and presents a valuable recreational area.

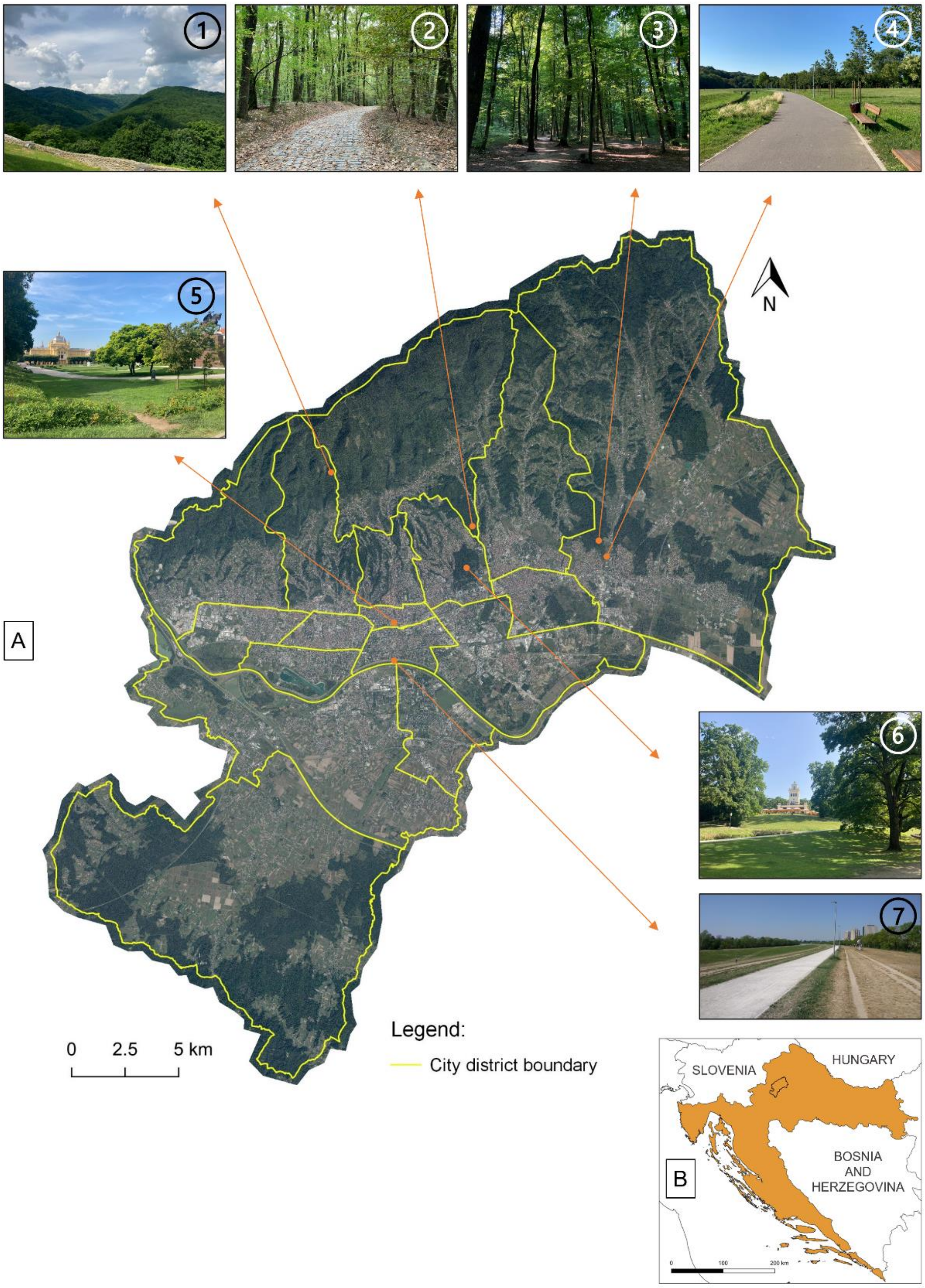

Figure 1. The study area. A) Digital orthophoto of the city of Zagreb (Croatian State Geodetic Administration) with city district boundaries (Open Street Map data) and photographs representing: 1) Nature Park Medvednica (M.K.); 2) Park Forest Dotrščina (M.K.); 3) Forest (M.K.); 4) Walking path along the stream (M.K.); 5) King Tomislav Square (part of Green

System) (M.K.); 6) Park Maksimir (M.K.); 7) Greenway along the Sava River (S.K.O.) B) Location of the study area in Croatia.

2.2. Selected cultural ecosystem services

We explored five CES categories, namely - place attachment, aesthetic experiences, recreation, cultural identity, and nature education. The employed categories are based on MEA (2005) classification, which is widely accepted, appropriately perceived, and used in scientific practice (Riechers et al., 2016; Cheng et al., 2019). These categories allow the interpretation and comparison between studies in order to explore a whole range of CES, including those categories known to be difficult to capture.

2.3. Focus group participatory mapping

Implementation of participatory mapping during focus groups interviews was similar to that reported in the scientific literature (Fagerholm et al., 2012; Lowery and Morse, 2013; Plieninger et al., 2013; Xu et al., 2020). We organized and conducted 20 focus groups with citizens of city districts, at least one in each city district in the period between 21 March and 11 November 2019 (Krajter Ostoić et al., 2020a). Focus groups took place at the premises of local self-government or in public libraries.

Each focus group was moderated according to the common protocol (the questions are presented in Table 1). Along with the discussion among focus group participants that was recorded and analysed separately, for which the participants gave their consent, the participants were also instructed to show green spaces where they perceived or experienced the CES category in question in the particular city district on a map. For mapping, colour and number-coded adhesive sticker dots were placed on the map. The participants were presented with the aerial map of the city district printed on an A0 sheet of paper. Aerial maps have previously been a useful tool used for workshop participatory mapping (Fagerholm et al., 2012). At the beginning of each focus group, the participants were introduced to the map and some of the main spatial points for orientation. They did not put markers on the map but only pointed to a location, while a member of the research team familiar with the coding was responsible for marking those locations. When participants were unable to show the exact location or sometimes had no knowledge of the name of a certain green space, they were instructed to describe it, and based on that description, the location was found and marked respecting the established coding protocol afterwards.

Table 1: Questions asked in focus group interviews related to specific cultural ecosystem services

CES	Question
Place attachment	What are your favourite urban green spaces in your city district and why?
Recreation	What urban green spaces in your city district do you visit the most and why?
Aesthetics	Are there any urban green spaces in your city district that you find beautiful (aesthetically pleasing)? Which are those and why?
Cultural identity	Are there any urban green spaces in your city district that you find important for the district's or Zagreb's cultural identity? Which are those and why?
Education	Are there any urban green spaces in your city district that you find important for the nature education of citizens? Which are those and why?

After the focus group interview, the socio-demographic data of participants were collected. The complete procedure of developing a focus group protocol and designing a socio-demographic questionnaire is presented in (Krajter Ostoić et al., 2020a).

Spatial markers were afterwards digitized into a GIS database. For this purpose, the QGIS software (v3.4.14) was used.

2.4. Spatial and statistical analysis

2.4.1. Spatial data analysis

Spatial markers were digitized respecting the CES category and coding. This allowed the connection of spatial data with participants' socio-demographic characteristics later in the analysis.

We delineated types of UGI under or near the digital markers using GIS. As a base layer, we used publicly available spatial datasets from the City of Zagreb as a reference (https://geoportal.zagreb.hr). Researchers who are well informed about the study area and moderated focus groups categorized UGI types marked by the participants. Categorization was accepted among the research team as representative for the study area. A 10 m buffer was added to extend the delineated area and to include spatial markers that are likely to be connected with a specific UGI type (Brown et al., 2014b).

Since tree-based UGI was the focus of this research, a subset of delineated areas containing trees resulted with tree-based UGI. For spatial analysis, we overlapped the tree-based UGI with layers of digitized markers representing CES. The frequency of placed markers of CES categories in each tree-based UGI type was calculated. Due to spatial diversity of city districts and a varied number of participants in focus groups, spatial markers were analysed based on the UGI type for the city as a whole.

2.4.2. Statistical data analysis

Descriptive statistics were performed on the collected spatial data and participants' socio-demographic data. We associated participant's socio-demographic information with the placed markers. To determine the number of participants who spatially perceived CES in a tree-based UGI, we assigned binary codes (1 = perceived, 0 = not perceived) to participants for each CES category separately.

To conduct correspondence analysis (CA) we used a contingency table of collected markers of CES categories in each tree-based UGI type (see Table 3). CA is performed to explore the relationship among multiple categorical data (Sourial et al., 2010; Bachi et al., 2020; Xu et al., 2020). The resulting CA biplot is a visual representation of the categorical data and their association, where the distance between variables represents relationships between them (Xu et al., 2020). The results were further complemented by calculating Spearman's rank correlation coefficients between CES and the associated tree-based UGI types using the same contingency table, resulting in a measure of statistical strength among the explored variables (Plieninger et al., 2013; Fagerholm et al., 2019; Bachi et al., 2020).

Statistical analyses were performed in R software (v3.6.2) using *FactoMineR* (Lê et al., 2008), *factoextra* (Kassambra and Mundt, 2020), and *ggplot2* (Wickham, 2016) packages.

3. Results

3.1. Socio-demographic characteristics of participants and CES perception

Altogether, 94 participants participated in focus groups. Socio-demographic profile of the participants is presented in Table 2. The majority were females and were highly educated (from undergraduate to PhD). More than half of the respondents were employed, while the rest were unemployed or retired. Prior to the focus groups, many had been living in Zagreb or in their respective city district for a long time. Two thirds of the respondents lived in apartment buildings.

Table 2. Socio-demographic profile of focus group participants

Variable	Category	N	%
Gender	Female	54	57%
	Male	40	43%
Age (years)	*Mean*	54	
	Min	26	
	Max	83	
Education	Elementary	3	3%
	Secondary	29	31%
	Higher	62	61%
Work Status	Employed	52	55%
	Unemployed/Retired	42	45%
Living in Zagreb (year)	*Mean*	43	
Living in city district (year)	*Mean*	33	

3.2. The proportion of perceived and mapped CES

The number of the collected spatial markers included in the analysis is 588 (Table 3). The highest number of markers was collected for place attachment, followed by aesthetics and recreational services. The smallest number of markers was associated with cultural identity and education (Table 4). Most of the participants were able to identify locations they perceive as bearing place attachment, followed by aesthetics and recreation, while every other or every third participant was able to identify locations perceived as those providing cultural identity and educational services in a city district, respectively. For each perceived CES, more than half of the participants were females.

Table 3. Frequency table of markers placed in a tree-based urban green space

UGI/CES	Place attachment	Aesthetics	Recreation	Cultural identity	Education	*Total*
Park	67	51	51	24	21	214
Forest	24	20	20	10	4	78
Park forest	32	6	15	11	4	68
Greenery of sport and recreational facilities	13	16	15	6	1	51
Treeline	16	26	4	3	1	50
Walking path along the stream	15	13	11	1	0	40
Greenway	13	9	9	2	0	33
The greenery around residential buildings	9	12	4	1	1	27
The greenery of the educational facility	4	2	2	3	3	14
Private garden	2	3	0	1	1	7
Single tree	0	3	0	0	0	3
Green system	1	0	0	0	1	2
Cemetery	0	1	0	0	0	1

Table 4. Distribution of spatial markers representing CES, the number of participants and their gender (N=94)

CES	N of markers	Proportion of markers	N of participants	% of participants	Points by gender (M / F)	Perception by gender (M / F)
Place attachment	196	33%	89	94%	41% / 59%	39% / 61%
Aesthetics	162	28%	71	75%	41% / 59%	39% / 61%
Recreation	131	22%	60	64%	47% / 53%	42% / 58%
Cultural identity	62	11%	46	49%	42% / 58%	39% / 61%
Education	37	6%	30	33%	43% / 57%	43% / 57%

3.3. Relationship between perceived CES and the types of tree-based UGI

In total, 13 different types of tree-based UGI were identified as providers of CES (Fig. 2). The average number of markers collected for one type of tree-based UGI was 45. Types of tree-based UGI with above the average number of collected markers were parks, forests, park forests, greenery of sports and recreational facilities, tree lines, walking paths along the streams, and greenway.

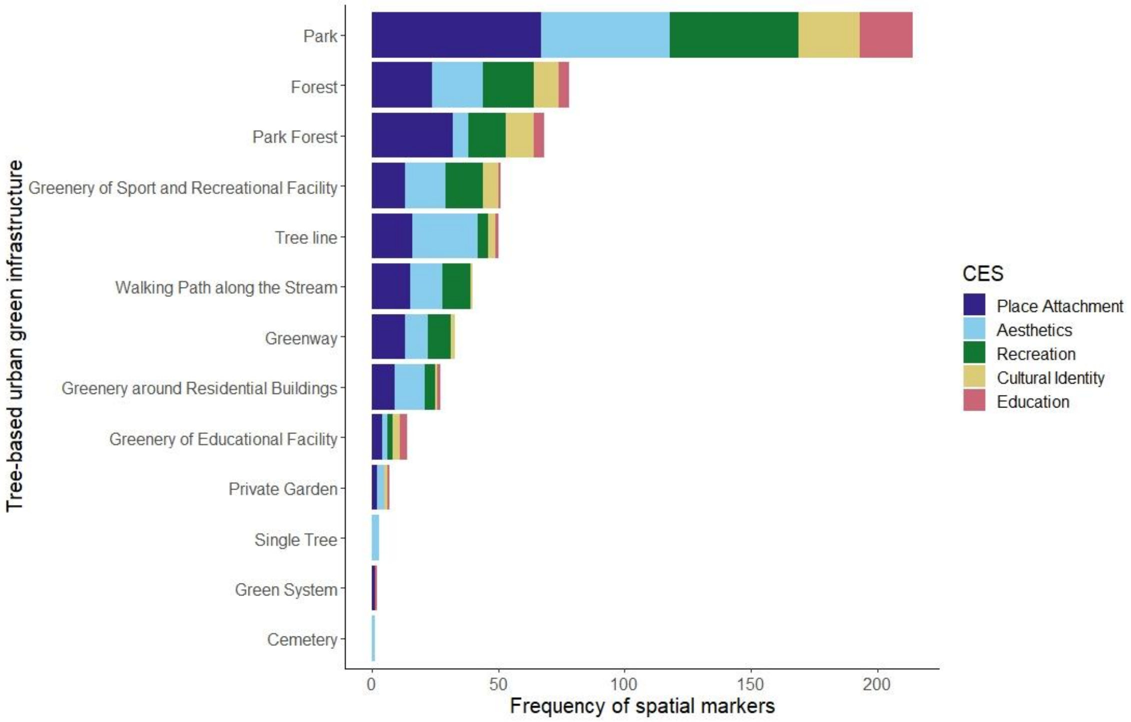

Figure 2. Frequency of spatial markers in tree-based urban green infrastructure differentiated by cultural ecosystem services (588 markers)

Before conducting CA, a contingency table was tested to see if the data was applicable for analysis. The calculated Chi-square of independence (with Monte Carlo simulation based on 1,000 replicates) between variables indicated that the data was appropriate for further analysis and interpretation ($\chi^2 = 86.96$, $p < 0.01$). CA resulted in a two-dimensional plot explaining 84.7% of the variance in the data (Fig. 3). First dimension (Dim1) explaining 58.9% of variability distinguishes aesthetics was associated mostly with tree lines, greenery around residential buildings, greenway, and to a lesser extent walking paths along the streams and greenery of sports and recreational facilities from other tree-based UGI. The second dimension (Dim2) explaining an additional 25.8% of variability emphasized recreation and education mainly associated with the greenway, walking paths along the streams, park forests, and greenery of sports and recreational facilities. Parks were perceived and used as versatile parts of tree-based UGI and therefore they are not linked to any CES, but rather they are providers of all CES indicated by their placement in the middle of a biplot. The cultural identity and educational services of a city district's UGI are less perceived among participants, also shown by the CA biplot. Only greenery around educational institutions, such as elementary schools and kindergartens, and a green system were perceived in connection with educational services. Complete contributions of CES and tree-based UGI to CA dimensions can be found in the Supplementary Material.

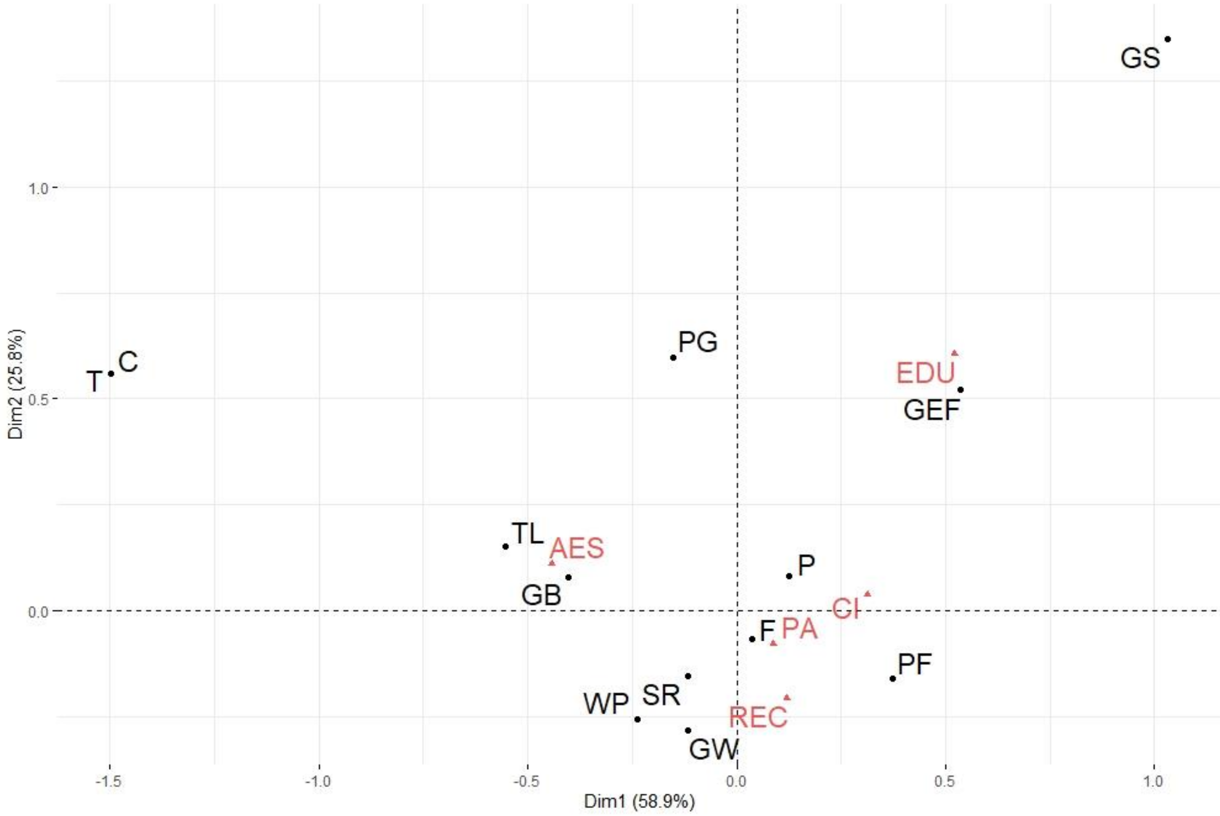

Figure 3. CA biplot of the first two axes representing a relationship between CES perception and tree-based UGI (triangles for CES, dots for tree-based UGI with abbreviations as follows: "T" – single tree, "C" – cemetery, "TL" – tree line, "GB" – greenery around residential buildings, "PG" – private garden, "WP" – walking path along the stream, "SR" – greenery of sports and recreational facilities, "GW" – greenway, "F" – forest, "P" – park, "PF" – park forest, "GEF" – greenery around educational facilities, "GS" – green system)

To explore further differences between the perception of CES categories and their distribution in a tree-based UGI, Spearman's rank correlation was used. The results show a statistically significant ($p < .01$ for bolded values, asterix for $p < .05$) correlation among the addressed CES categories (Table 5). The highest correlation value is calculated between place attachment and recreation, meaning that people are attached to that tree-based UGI which they most frequently use for recreation and vice versa. Place attachment is also highly and significantly correlated with cultural identity, and significantly but less strongly with aesthetics and education. Aesthetics is significantly correlated with place attachment and recreation. Recreation is significantly correlated with all services but education. Cultural identity is significantly correlated with all services. Education shows a weak and non-significant correlation with other services, except with cultural identity and place attachment, which is also in line with the results of CA.

Table 5. Correlation matrix (Spearman's rank) for mapped cultural ecosystem services

	Place attachment	Aesthetics	Recreation	Cultural identity	Education
Place attachment					
Aesthetics	**0.81**				
Recreation	**0.92**	**0.81**			
Cultural Identity	**0.89**	0.69*	**0.87**		
Education	0.63*	0.36	0.56	**0.79**	

4. Discussion

CES are rarely addressed on a city level (Hegetschweiler et al., 2017), thus this study covered the whole city of Zagreb by conducting focus groups in each city district. As a result, detailed spatial data for the entire city was gathered based on the residents' perception of CES provided by tree-based UGI in their city districts.

Studies focusing on the perception of CES usually target only one or a few types of UGI, with forests and parks being the most frequent (Hegetschweiler et al., 2017). However, our participants could reflect on and map any type of UGI. As a result, participants mapped their perception of CES in relation to 13 types of tree-based UGI. Some of these were not often covered in similar studies (e.g., greenery of sports and recreation facilities, cemeteries) (Beichler, 2015; Ives et al., 2017; Pietrzyk-Kaszyńska et al., 2017; Riechers et al., 2019).

The workshop participatory mapping approach is more flexible because it combines qualitative and quantitative data collection at the same time (Brown et al., 2014a). Qualitative data provided clarification about locations and UGI types while digitizing collected spatial markers. The approach resulted in detailed information that allowed a better understanding of the perception of different tree-based UGI types and relationships with CES than it was the case in previous studies (Beichler, 2015; Rall et al., 2017). Furthermore, this work provides valuable results also important to the local context of the city of Zagreb by complementing the results of qualitative analysis on focus group data (Krajter Ostoić et al., 2020a) and other recent research on the UGI in Zagreb (Krajter Ostoić et al., 2017; Kičić et al., 2020).

The gathered sample of 94 participants is in line with the number of participants involved with research using a similar data collection approach (Lowery and Morse, 2013; Plieninger et al., 2013). Compared to Zagreb's population census, focus group participants were balanced by gender, with slightly more women participating than men. Most age groups were covered, but with an evident underrepresentation of younger age groups and overrepresentation of older participants compared to census data. Also, there was an overrepresentation of participants with higher education and an underrepresentation of participants with lower education. However, overrepresentation women and highly educated participants was also found in similar studies (Krajter Ostoić et al., 2017; Rall et al., 2017; Kičić et al., 2020)

4.1. Perception of CES and tree-based UGI in Zagreb

Our results are consistent with literature findings regarding the fact that parks and forests are the most pronounced types of UGI (Rall et al., 2017). Parks are widely explored as being one of the most important green spaces in cities (Brown et al., 2014b; Bertram and Rehdanz, 2015; Zwierzchowska et al., 2018; Dade et al., 2020). Throughout Europe, more than 50 different motivations for visiting parks and numerous types of enjoyment when visiting were expressed by people (Vierikko et al., 2020). Therefore, it is no wonder that in Zagreb's city districts, parks are also perceived as providers of all CES and acknowledging their role as one of the most important elements of UGI. Placement of parks in the CA biplot near the intersection of axes indicates their role as a foundation for the provision of all CES.

Historically important parks such as Maksimir are fairly present in the city of Zagreb. Established in 1794, Maksimir was the first public park in Southeast Europe (Maruševski and Jurković, 1992). It is certainly the most well-known and popular park even for people who do not live in Zagreb. However, since focus groups were conducted with residents in each city district, researchers learnt about various locally important parks which are important for nearby residents as well as for the entire city, verifying the emerged perception of parks as holders of cultural identity values.

Alike parks, forests and park forests are widely explored types of tree-based UGI in relation to human preferences and provision of recreational services (Arnberger, 2006; Ciesielski and Stereńczak, 2018; Korpilo et al., 2018; Baumeister et al., 2020). In this study a large number of markers were collected throughout the city for these tree-based UGI. They were perceived as holders of all explored CES, with an emphasis on recreational use and place attachment values. Due to a significant amount of forested area in Zagreb, this poses an important result for forest planning and management, especially for park forest management where the provision of CES is the main goal.

Since this study explored the relationship between the perception of CES and tree-based UGI on a smaller scale, we managed to find types of tree-based UGI less presented in scientific literature that are related to the perception of CES. Some of them are greenways, walking paths along the streams, tree lines, and greenery around residential buildings. Greenways and walking paths along the stream in Zagreb are perceived mostly in relation to place attachment, aesthetics, and recreational values, collecting the above-average number of spatial markers. Greenways are important for citizens since they are large, open, and accessible green areas in the city. The revealed perception and use of greenways in Zagreb is comparable to the perception expressed for Caldes Stream Corridor in Barcelona, where recreational, cultural, and aesthetic values were highlighted for the area (Garcia et al., 2017). With its historical and cultural significance, the greenway is also perceived as part of the cultural identity values in Zagreb; however, it is not perceived as a provider of educational services neither quantitatively nor qualitatively (Krajter Ostoić et al., 2020a). The reason may be the lack of infrastructure and organized activities or not meeting certain expectations that of the participants in terms of educational potential (Krajter Ostoić et al., 2020a). Walking paths along the streams are an important element in cities that contribute to the spatial connectivity of the UGI. Water is an important element in the urban landscape that together with accessibility influences the perception and use of green spaces in cities (Scott Shafer et al., 2013)

Perception of tree lines in the context of CES has not been so often mentioned in scientific literature. Trees are an important building element of UGI not just from an ecological point of view, but also psychological and aesthetic (Tyrväinen et al., 2005). Aesthetic benefits arise from colours, textures, forms and densities (ibid.). Tree lines in Zagreb's city districts are predominantly perceived as holders of different aesthetic experiences. With more than 200 km of tree lines in Zagreb, this result is important for tree planning and management practices in Zagreb. A recent study from Porto shows that tree lines are mostly valued for environmental services. However, cultural ecosystem services prove to be almost equally important (Graça et al., 2018). Further, research shows that aesthetics is almost universally highly appreciated and an important category of CES in cities (Kyttä et al., 2013; Buchel and Frantzeskaki, 2015; Dou et al., 2017; Ives et al., 2017).

Cemeteries are perceived as valuable places in cities, holding restorative potential for the city dwellers. This potential emerges from the combination of highly maintained natural elements, especially trees and flowers, quiet environment, recreational potential, along with historical and cultural values they hold (Nordh et al., 2017). Cemeteries in Zagreb resulted in being perceived as holders of aesthetic experiences. Although cemeteries are an important part of UGI and partake in the provision of CES, they were less perceived in Zagreb. This could be due to a data collecting approach where only UGI located within the city district were discussed, while not every district has a cemetery that they could refer to.

The greenery around residential buildings is important for everyday use, although it is still an under-explored type of UGI (Säumel et al., 2021). Our participants perceived those spaces more in the context of aesthetics and less in regard to active use. This is similar to the results of the aforementioned study where passive uses are preferred over active ones and where the majority of residents perceived enjoying of natural sounds and different plants and trees (ibid.). There was also a higher appreciation of aesthetics in residential green spaces than of recreation possibilities (Mao et al., 2020). Characteristics of this UGI type could be the reason why they are not more important in terms of (active) recreation in Zagreb, e.g., they are too small for long-lasting or long-distance activities (running or riding a bicycle), or they lack the equipment that people prefer for recreational purposes. This might be in contrast to a recent Swedish study showing that recreationists use nearby landscape types regardless of landscapes characteristics (Lehto et al., 2022). However, this type of UGI was perceived as a provider of all CES, hence indicating a need for further exploration. Private gardens were associated with similar perceptions as greenery around residential buildings, although they were less mentioned by participants. A possible explanation for this is that half of the participants live in apartment buildings and therefore do not have a private garden to refer to. However, private gardens presented an important refuge place during COVID-19 pandemic (Poortinga et al., 2021).

Education is usually weakly perceived or explored as a benefit of UGI (O'Brien et al., 2017; Lopez et al., 2021). Educational service (education in nature) was the least perceived CES provided primarily by forests, parks, and greenery of educational facilities. The results of qualitative analysis of focus group interviews show that the educational services also elicited a weak discussion among the participants (Krajter Ostoić et al., 2020a). The reason may be that people have different ideas of what education in nature is or should be. For some participants, any green space can be used for educational purposes, and for others, those UGI should have certain attributes, such as being close to educational institutions as in our case (kindergartens, schools, or faculties), having certain facilities or at least nametags on trees. Teaching outdoors is part of the school curricula in Croatia and school gardens are designed with the aim of education, hence our results and perception participants hold towards them are in line with their primary function. Nevertheless, educational values are difficult to spatially capture, which is a conclusion similar to one proposed for the city of Berlin (Rall et al., 2017).

4.2. Patterns in CES perception

The patterns in CES perception regarding tree-based UGI in Zagreb were explored by employing CA and complemented with calculating correlations. Aesthetics emerged as differently perceived from other CES categories in relation to tree-based UGI, forming the first perception bundle. Recreation and place attachment and their respective connected tree-based UGI influenced the second bundle of perception mainly characterized with tree-based UGI having a utilitarian character. Larson et al. (2019) came up with similar results by distinguishing two subdivisions of perception of ecosystem services in a neighbourhood environment – one connected with aesthetic experiences and the other with recreational values and possibilities. The CES categories of place attachment and recreation are highly correlated in relation to their manifestation in tree-based UGI, supporting the claim that recreation can be an underlying goal for interaction with green spaces (Riechers et al., 2016; Krajter Ostoić et al., 2020a). Correlation between the perception of CES categories resulted in high and significant correlation coefficients among some of them. This can indicate similar perceptions and use of those UGI types (Riechers et al., 2019).

Although parks are perceived as providers of all CES, other types of tree-based UGI can be associated with specific purposes and perception. This information could be of interest to decision-makers and planning experts, and it is also a valuable starting point for researchers when exploring further tree-based UGI and the perception of CES. Even though patterns of CES provision were detected, high and significant correlation coefficients among variables indicate that most of the CES categories are not stand-alone, but they spatially coexist and synergistically act in the perception of people. Finally, the results show a more synergistic nature of CES (Plieninger et al., 2013; Rall et al., 2017). This adds to the need for the assessment of mutual relationships among ecosystem services (proposed by Haase et al., 2014).

4.3. Perception of tree-based UGI in Zagreb in a broader context

Zagreb as a postsocialist city shares some of the problems with other similar cities in Eastern Europe, such as the shift to neoliberal market capitalism which impairs the importance of green spaces at the expense of construction sites (Kronenberg et al., 2020). A serious threat for postsocialist cities is the ownership change from public to private and loss of green space. For example, Bucharest in Romania lost 34.5% of its urban parks to impervious surfaces, consequently influencing the perception and use of green spaces (Iojă et al., 2011). A similar outcome was also observed in Poland (Kronenberg et al., 2021). In Zagreb, with no structured inclusion of citizens in green space management other than a public exhibition of plans to the (un)interested public, public participation is acknowledged as one of the elements of urban green space governance that needs to be improved (Krajter Ostoić, 2013).

Exploring the perception and satisfaction with green spaces in Zagreb and other cities that emerged from the former Socialist Federal Republic of Yugoslavia, differences in perception and satisfaction with UGS were found (Krajter Ostoić et al., 2017). Some of them are differences in the perception of general green space importance, the need for more green spaces, or the importance of various negativities such as litter, access to green spaces or vandalism. This indicates that although these cities share similar development practices due to shared history, the local context is also important in exploring the perception of UGI. The results of this research are in line with previous research related to UGI in postsocialist cities, which also enables comparison with the results obtained in western European cities and across different types of tree-based UGI (Garcia et al., 2017; Rall et al., 2017; Säumel et al., 2021).

4.4. Limitations

Participatory mapping on a small scale can yield a more detailed view of the city district's UGI, but practitioners should be careful when aiming at the generalization on a city scale for planning purposes due to the purposive sample of participants and the diversity of spatial characteristics in each city district. Furthermore, sociodemographic background of our participants is not representative of the city's population. However, our approach enabled finding patterns that would not otherwise be possible.

5. Conclusions

In this paper, we quantitatively explored the interrelation between the perception of CES and tree-based UGI in the city of Zagreb in all city districts. The results show that although place attachment, aesthetics, and recreation are more frequently perceived, our participants overall perceived all explored CES on a city district level, even those known as being hard to capture or less pronounced, such as cultural identity and education. Also, we found that besides parks and forests, there are other types of tree-based UGI perceived and used in relation to CES. With specific attention put on tree-based UGI, we demonstrated that UGI that contains trees is an important part of UGI in cities and partakes as a provider of CES. Additionally, this research demonstrates the data collected and the results gathered with an extensive participatory mapping throughout the city of Zagreb and in direct contact with city inhabitants. The results, especially those regarding less pronounced types of tree-based UGI, could help decision-makers, planners, and managers to better address a variety of tree-based UGI types and maintain them in a way that they keep providing various CES to citizens.

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Conflict of interest

The authors declare no conflict of interest.

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Supplementary Material

Table 1 - Contribution of CES over the first four dimension of CA (abbreviations as follows: PA – Place Attachment, AES – Aesthetics, REC – Recreation, CI – Cultural Identity, EDU – Education)

	Dim 1	Dim 2	Dim 3	Dim 4
PA	2.980242	5.4370986	55.869346	2.379980
AES	61.875001	8.6385048	1.353007	0.582466
REC	3.656283	24.9425464	39.507239	9.615019
CI	11.856987	0.4125539	1.716304	75.469937
EDU	19.631487	60.5692962	1.554103	11.952597

Table 2 - Contribution of tree-based UGI over the first four dimension of CA

	Dim 1	Dim 2	Dim 3	Dim 4
Park	6.5578499	6.3222857	9.0545719	6.9794680
Forest	0.2216858	1.5832821	5.6684760	5.3140090
Park forest	18.5029425	7.7045035	33.7060974	11.7552239
Greenery of Sport and Recreational Facility	1.3261706	5.4093754	22.1099089	5.1874029
Tree line	29.7764627	5.0878173	15.3183670	4.8752959
Walking Path along the Stream	4.3876004	11.6212924	0.6752529	21.8105900
Greenway	0.8696376	11.7601464	1.5465193	4.4201262
Greenery around Residential Buildings	8.5066357	0.7637458	3.4598364	2.8791518
Greenery of Educational Facility	7.8235109	16.8907608	0.3454544	4.5370287
Private Garden	0.3200424	11.0687580	1.8299156	4.0280293
Single Tree	13.1569705	4.1864041	1.7996283	1.2441415
Green System	4.1648339	16.2061604	3.8860959	26.5548190
Cemetery	4.3856568	1.3954680	0.5998761	0.4147138