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Relationships among satisfaction, noise perception, and use of urban green spaces

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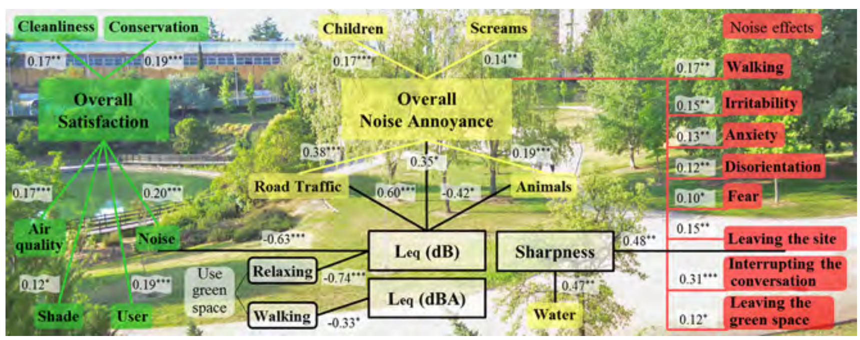
HIGHLIGHTS

- Noise is the most influential factor in the evaluation of an urban green space.
- Road traffic remains the fundamental source of noise in urban green spaces.
- For the same sound level, noise annoyance is lower than in other urban areas.
- L_{eq} (dB) and sharpness proved to be good estimators of noise perception.
- The lower the noise, the higher the frequency of relaxation and walking activities.

GRAPHICAL ABSTRACT



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ABSTRACT

Nowadays, urban design without green spaces is inconceivable. Environmental, social, and economic benefits generated by green spaces are essential to maintain the health and quality of life of the population and to control pollution. Therefore, urban planners and city leaders should know the interactions between the features of green spaces, the sociodemographic characteristics of users, and the type of use. In addition, in some studies, noise was found to be an essential factor in the perception of these green spaces. For this purpose, surveys and sound measurements were carried out simultaneously in different locations of the main green spaces of Cáceres city. The results of this study show that noise satisfaction has the greatest significant relationship with overall satisfaction with green spaces. Different features, including satisfaction with the absence of noise, can explain 71.4% of the overall satisfaction. Road traffic is the most annoying sound source, but the degree of noise annoyance is lower than that estimated for other urban environments with similar sound levels. Walking and talking activities, emotions of fear and irritability, and interruptions to conversation are most often affected by noise in these urban environments. Another conclusion obtained is that the highest significant correlation coefficients are between noise perception by users and both the equivalent continuous linear weighted sound level and sharpness. Lastly, the green-space use determines differences and significant relationships with the sociodemographic characteristics. Also, the places in green spaces where people frequently perform walking and relaxation activities have the lowest sound levels. Therefore, noise is a statistically relevant factor to be considered in the design of green spaces.

1. Introduction

In the last decades, there has been a clear trend toward the depopulation of rural areas and increasing concentration of human beings in

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cities. Currently 57% of the population live in agglomerations having populations in excess of 300,000 people, and it is estimated that by the year 2030, 62% of the global population will live in cities (UN, 2014).

The rapid growth of cities has brought social, economic, and environmental challenges (EC, 2000). Five objectives in the environmental dimension have been defined for a European vision of tomorrow's cities: mitigate and adapt to climate change; protect, restore, and enhance biodiversity and ecosystems; reduce pollution; manage natural materials resources sustainably and prevent waste; and protect, preserve, and manage water resources (RFSC, 2016). Populations are living in environments with increasing pollution, intense heat, habitat loss, declining biodiversity, and noise (EEA, 2014, 2016; IEAGHG, 2016; RFSC, 2016). Approximately seven million people died in 2012 due to exposure to air pollution (WHO, 2014), and 60,000 disability-adjusted life years are lost through ischaemic heart disease due to environmental noise (WHO, 2011). There is a critical need to find ways to reduce health risks and improve the wellbeing of citizens.

Studies from numerous fields have analysed the benefits provided by urban green spaces in cities and they are related with three key values: social, economic, and environmental (Chiesura, 2011; Sander, 2015; Scopelliti et al., 2016; Szeremeta and Zannin, 2013). Urban green spaces play an important role from a social perspective by promoting physical activity, allowing rest or relaxation and increasing social interaction (Dadvand et al., 2016; Kaczynski et al., 2008; Maas et al., 2009; Peters et al., 2010). They therefore help to facilitate active lifestyles and emotions of restoration while reducing stress and social isolation in urban environments (Coombes et al., 2010; Grahn and Stigsdotter, 2003, 2010; Jay and Schraml, 2009). Urban green spaces also benefit local residents and communities economically. Aesthetic and recreational values of urban green spaces increase the attractiveness of a city and promote it as a tourist destination, thus generating employment and revenue (Jim and Chen, 2006). Water and vegetation also increase property values (Luttik, 2000; Sander and Haight, 2012). The other key value of urban green spaces is environmental benefits, such as counteracting the urban heat island effect (Doick et al., 2014; Feyisa et al., 2014), reducing air pollution (Cohen et al., 2014; Yin et al., 2011), mitigating runoff (Xiao et al., 1998), and maintaining urban biodiversity (Alvey, 2006; Paker et al., 2014). Consequently, due to the range of social and environmental services they afford, urban green spaces are a public good and their availability is a core indicator for a sustainability profile (EC, 2000).

Noise pollution ranks second among a series of environmental stressors in terms of public health impacts (WHO, 2011). The existence of "quiet areas" is among the objectives of the European noise policy (EC, 2002). However, some studies show that noise levels in urban green spaces are not significantly lower than those in the typical home environment (Cohen et al., 2014; Martínez Suárez and Moreno Jiménez, 2013; Lam et al., 2005; Tse et al., 2012; Zannin et al., 2006).

Urban green space functionality and outcomes are closely related to their features (Dzhambov and Dimitrova, 2015). Recent studies relate some features or uses of urban green spaces to the benefits they provide (Dadvand et al., 2016; Scopelliti et al., 2016). However, studies analyzing the relative contributions of the different features of green spaces to the overall explanation of their functionality remain scarce.

In this study, the features of green spaces were evaluated through the perceptions of users and, from these perceptions, their relationships with respect to the overall satisfaction with the green areas were analysed. The extent to which a user takes into account the features of a green space when giving it an overall assessment is a very important aspect for urban planners and city leaders. Thus, core indicators for a local sustainability profile were evaluated: availability of local public green areas and citizens' satisfaction with the local community (EC, 2000).

Because of the importance of noise satisfaction in the overall assessment of green areas, another objective of the study was to analyse the annoyance caused by noise sources and their effects on users' activities and attitudes.

Finally, satisfaction with the features of green spaces, the annoyance caused by noise, and the effects of noise were related to the sociodemographic characteristics of the users. In addition, the relationship between these aspects and the activities carried out by users in urban green spaces was analysed. These results could also be used by urban planners when designing green spaces for certain uses.

2. Methodology

2.1. Study area

The study was carried out in green spaces of Cáceres, a medium-sized city located in the southwest of Spain, whose proportion of green area per inhabitant is approximately 16.6 m^2 per inhabitant. This proportion is one of the highest in the country and is greater than the range of 10–15 m^2 per inhabitant recommended by the World Health Organization (Brebbia et al., 2010).

The following urban green areas were selected for this study: Cánovas, Principe, Valhondo, Fernando Turégano, Fray Pacífico, Perú, and Rodeo. Locations and aerial photos of the green spaces are shown in Fig. 1. The green spaces were chosen on the basis of location, size, and year of inauguration (see Table 1).

These green spaces are located in densely populated urban areas and are representative of the different districts. They are popular green spaces frequently visited by citizens in Cáceres. The selected green spaces were large enough for the activities analysed later in the survey. The age of the green spaces made it possible to analyse the evolution of satisfaction regarding the features evaluated in previous studies.

2.2. Surveys

A cross-sectional study was carried out during 2014 by means of questionnaires administered during daytime to a random sample of adult visitors to the seven urban green spaces selected. Face-to-face interviews were conducted by trained interviewers. During the survey, respondents were informed about the objectives of the study and the time required to complete the questionnaire (about 10 min). A total of 182 completed questionnaires were used for this study. The percentage of respondents compared to the total number of citizens was similar to that used in recent studies (Dzhambov and Dimitrova, 2015; Kaczynski et al., 2008) with a sufficient statistical power (Fritz and Mackinnon, 2007). The questionnaires were well distributed in terms of district, sampling points, size of green space, and number of visitors. In this way, the sample presented sociodemographic characteristics representative of the population resident in Cáceres (see Table 2).

In each urban green space, the sites most frequented by visitors were selected to conduct the surveys and the acoustic measurements (see Fig. 1). Interviews and acoustics measurements were carried out simultaneously.

In the survey, three dimensions were analysed: satisfaction (12 items, $\alpha_{Cronbach} = 0.79$), noise annoyance (8 items, $\alpha_{Cronbach} = 0.70$), and effects of noise (14 items, $\alpha_{Cronbach} = 0.81$). The items were rated on a five-point Likert scale ranging from 0 ("not at all" or "never") to 4 ("a lot" or "very often").

In the first dimension, the satisfaction with the features of urban green spaces was analysed. The following items were evaluated: cleanliness, air quality, noise, aesthetics, safety, users, conservation, location, size, groves, and shade. These features were selected due to their relationship with social, economic, or environmental aspects that influence the overall satisfaction with green spaces. Overall satisfaction was also evaluated in one item. The cleanliness, aesthetics, and conservation along with environmental features such as groves have an influence on the visual assessment of the green space. In turn, these features influence the overall valuation and can influence the valuation of other

Fig. 1. Map of Cáceres city (Spain) with location of the selected green spaces and sampled sites (images from Google Earth). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Table 1
Year of inauguration, area, and distance from the city centre of the green spaces.

Urban green spaces	Year of inauguration	Area (hm^2)	Distance from the city centre (km)
Cánovas	1895	2.1	Downtown
Príncipe	1970	22.0	0.5
Valhondo	2001	2.2	1.3
Fernando Turégano	2000	3.2	2.0
Fray Pacífico	1998	1.6	1.0
Perú	2002	1.5	0.8
Rodeo	2001	10.6	0.8

environmental features such as noise (Carles et al., 1999; Preis et al., 2015). Noise, air quality, groves, and shade are features to be considered in assessing the environmental benefit of green spaces, as recent studies have shown (Jabben et al., 2015; Shen and Candice Lung, 2016). Besides, social and design aspects such as security, users, size, and location should be considered. Recent studies show that the locations and proportion of green spaces have a significant influence on healthy habits (Dadvand et al., 2016; Scopelliti et al., 2016; Shen and Candice Lung, 2016). However, the function and assessment of these features may be influenced by social characteristics, such as the relationship with users or security (López Barrios, 2001).

Table 2
Sociodemographic and green-space-use characteristics of the sample.

Variable	Sample (%)	Cáceres (%) (INE, 2015)
Age		
18–25 years	17.0	9.8
26–35 years	15.4	17.8
36–45 years	23.6	20.8
46–55 years	12.1	20.0
56–65 years	11.0	13.7
>66 years	20.9	17.9
Sex		
Male	47.3	48.2
Female	52.7	51.8
Education		
Missing	8.1	8.8
Primary or secondary school	37.5	35.2
Highschool	24.5	25.3
Degree	29.9	30.8
Work activity		
Worker	41.8	40.9
Unemployed	15.4	14.2
Retired	17.0	16.4
Homemaker	16.5	7.5
Student	9.3	21.0
Main activity in the green space[a]		
Reading	3.3	
Taking children out	20.9	
Relaxing	25.3	
Exercising	25.3	
Walking	60.4	
Talking	54.9	

[a] Percentage of the sample whose activity is carried out “very often” or “often”.

Table 3
Average level of satisfaction with the features of urban green spaces, analysis of the significance of the differences in average values of satisfaction between the years 2007–2008 and 2014, and bivariate correlations between the features of and overall satisfaction with urban green spaces in 2014.

Features	Level of satisfaction (scale 0–4)				p-Value[a]	Correlation with overall satisfaction in 2014
	2014		2007–2008			
	Mean	Median	Mean	Median		R[b]
Cleanliness	3.0	3	2.9	3	>0.05	0.37***
Air quality	2.7	3	2.6	3	>0.05	0.40***
Noise	2.4	2	2.4	3	>0.05	0.42***
Aesthetics	3.2	3	2.9	3	<0.001	0.34***
Safety	3.5	4	2.5	3	<0.001	0.21**
User	3.0	3	2.6	3	<0.001	0.22***
Conservation	3.2	3	2.9	3	<0.001	0.32***
Location	3.7	4	3.0	3	<0.001	0.16*
Size	3.6	4	3.0	3	<0.001	0.25***
Shade	3.2	3	2.1	2	<0.001	0.30***
Groves	3.2	3	2.2	2	<0.001	0.28***
Overall	3.1	3	3.0	3	>0.05	–

[a] Mann-Whitney test.
[b] Correlation coefficient (Kendall's tau–b).
* Significant at $p \le 0.05$.
** Significant at $p \le 0.01$.
*** Significant at $p \le 0.001$.

Also, in 2007–2008, the satisfaction dimension was studied in the same green spaces using the sampling procedure employed in this study and interviewing 234 users. The results of that analysis showed that noise was one of the environmental features with which users were less satisfied (see Table 3). Therefore, because of these results and the current interest in this environmental pollutant, in the present study, noise annoyance and noise effect dimensions were analysed.

On the noise-annoyance dimension, the annoyance caused by the main sound sources in urban green spaces, such as road traffic and sounds from people (voices, children, construction sites, maintenance services), was evaluated (Benfield et al., 2010; Szeremeta and Zannin, 2009; Torija et al., 2014). In addition, sounds from animals and water, which are features of these urban spaces, were evaluated (Barrigón Morillas et al., 2013). Lastly in this dimension, users were asked about the overall noise annoyance in urban green spaces.

With regard to the noise effects dimension, the frequency of noise-induced emotions (irritability, anxiety, disorientation, fear, earache), the frequency with which the activities carried out in green spaces (talking, reading, relaxing, walking, exercising) were disturbed by noise, and the actions induced by noise (increasing conversation volume, interrupting conversation, leaving the site, leaving the urban green space) were evaluated.

Finally, the sociodemographic characteristics and green-space use were registered.

2.3. Acoustic data

As indicated above, the sites most frequented by visitors were selected for performing the surveys and acoustic measurements simultaneously. The number of sampling points was determined by the size of green spaces and the variety of soundscapes. This is similar to that used in recent studies (Szeremeta and Zannin, 2015; Paneto et al., 2017). Fig. 1 shows the locations of sampling points in each urban green space.

The measurement campaign was carried out from 10:00 to 21:00 h during week days and weekends. The sound levels were measured with a Brüel & Kjaer 2238 sound-level meter and a binaural recording device (Noise Book from Head Acoustics). Thus, the sound descriptors L_{Aeq}, L_{Amax}, L_{Amin}, L_{A1}, L_{A5}, L_{A10}, L_{A90}, L_{A95}, L_{A99}, and L_{Cpeak} were registered. These sound descriptors have been used in numerous current studies to characterize sound environments (Szeremeta and Zannin, 2009; Torija et al., 2014; Tse et al., 2012; Yu and Kang, 2014). Also, the sound descriptors L_{Aeq} and L_{eq} were registered with a binaural recording device, which also analysed psychoacoustic indicators such as loudness and sharpness. Some authors indicate that binaural recording is more useful than other methods because it is possible to recreate the spatial characteristics of the sound environment (Jeon et al., 2013).

Measurements followed ISO 1996–2 standard guidelines (Barrigón Morillas et al., 2016; ISO 1996–2, 2007), which meant that the microphone was placed at a height of 1.5 m in free-field conditions. At each sampling point, a 10-min measurement was performed every time a survey was conducted. The duration of sound measurement was considered sufficient considering previous studies carried out in urban parks (Axelsson et al., 2014; Jabben et al., 2015; Liu et al., 2014; Lobo Soares and Bento Coelho, 2016; Szeremeta and Zannin, 2009; Zannin et al., 2006).

2.4. Statistical analysis

Firstly, a descriptive analysis of the average valuations (mean and median) given by users to the items of the three dimensions analysed was carried out. These results show the users' perceptions of the urban green spaces. In the case of the satisfaction dimension, the results were compared with the average values obtained for the years 2007–2008. For this purpose, the non-parametric Mann-Whitney test was used because the variables were categorical.

Also, within the descriptive or exploratory analysis, a hierarchical cluster analysis was carried out. This procedure attempts to identify natural groupings (or clusters) within a variable set (Aldenderfer and Blashfield, 1984). Hierarchical cluster analysis first separates each variable into a cluster by itself. At each stage of the analysis, the two nearest clusters (the most similar clusters in terms of distance) are joined until all of the variables are joined in a complete classification tree. This tree diagram is called dendrogram. In the dendrogram, the clusters are represented by horizontal lines and the stages of the merger by vertical lines (see Fig. 2). The separation between the stages of the merger is proportional to the distance at which the clusters are joining at that stage. However, the distances are not represented in their original scale but in a standardised scale of 25 points (rescaled distance). As in previous studies (Brambilla et al., 2013; Nilsson and Berglund, 2006; Rey Gozalo and Barrigón Morillas, 2017), the merger was stopped when the clusters which were going to be joined were significantly more distant than those previously merged. Thus, the rescaled merger distance was lower than 15 in Fig. 2(a) and it was 15 in Fig. 2(b). There are different types of measures to estimate the distance between variables or clusters. Also there are different cluster methods. Cluster method defines the rules for cluster formation and the measure defines the formula for calculating distance among clusters. Ward's method was used in this study. In this method, at each step, the two clusters that merge are those that result in the smallest increase in the overall sum of the squared of the differences, within each cluster, of each individual to the centroid of the cluster (Murtagh and Legendre, 2014). Kuiper and Fisher (1975) proved that Ward's method carried out a better classification than other methods. Therefore, this hierarchical method is one of the most used. For example, Brambilla et al. (2013) and Nilsson and Berglund (2006) have used Ward's method in studies performed in urban parks. With respect to the measure to estimate the distance, the chi-squared measure was used in this study because the variables are categorical (Greenacre, 1988; Hussain and Asghar, 2016). The items are ranging from 0 (“not at all” or “never”) to 4 (“a lot” or “very often”).

Secondly, the relationships between the different variables registered in the study were analysed. First, within each dimension, the relationship of each item with its overall valuation (satisfaction or noise annoyance) was analysed. For this purpose, bivariate and partial correlations (Kendall's tau-b) were used. The partial correlations show the relationship between two variables controlling the possible effects of the rest of the variables in the same dimension (Kim, 2015). In the case of the satisfaction dimension, a multinomial logistic regression model was created from variables (features) which had a significant relationship with the overall satisfaction. Methods for stepwise selection of variables (forward and backward) and the likelihood ratio tests to check the contribution of each variable to the model were used. Also, the results obtained in the hierarchical cluster analysis (features within the same cluster have a similar frequency with respect to the users' valuations and, therefore, could have collinearities) and in the partial correlation (features with a higher correlation coefficient with overall satisfaction after eliminating the possible influence of the other features) were considered in the selection of predictors. For each variable, the − 2 log-likelihood is computed for the reduced model; that is, a model without the variable. The chi-squared statistic is the difference between the − 2 log-likelihoods of the reduced model and the final model. If the significance of the test is <0.05, the variable contributes to the model. Also, the likelihood ratio test shows if the final model fits the data better than a null model. For the final model, chi-squared statistic is the difference between the − 2 log-likelihoods of the null and final models. If the significance level of the test is <0.05, the final model is outperforming the null.

Also, within the analysis of the relationships between variables, the mean values of the subjective perceptions to the noise in the sampled points were related to the levels of the registered sound indicators (Rho Spearman). Finally, the correlation between the items registered in the three dimensions and the sociodemographic characteristics and green space use (Kendall's tau-b) was analysed.

3. Results and discussion

3.1. Satisfaction with urban green spaces

Table 3 shows the development of the level of user satisfaction with the features of green spaces of Cáceres. Currently there is a very good perception of the size and distribution of green spaces in the urban area, with average values of 3.7 and 3.6 for location and size, respectively. These valuations have increased compared to the study performed in 2007–2008 because of improvements in use options (creation of play and sports areas) and because of the population growth in the peripheral neighborhoods.

The age of green spaces is reflected by the average satisfaction with the shade and groves, valued at 3.2. The satisfaction with these features has increased significantly in the last six years. Also, green spaces have water fountains and their own gardening and cleaning service, which contribute valuations of 3 (“quite”) to 4 (“a lot”) to the average satisfaction with regard to the features of aesthetics, cleaning, and conservation.

At the entrance to the green spaces, the rules of behaviour and the regulations regarding opening and closing are shown. This contributes to the fact that direct and indirect relations between users and safety can be considered quite good, with ratings between 3 and 4. Some incidents prior to 2008 led the council to limit the access to the green spaces and increase their security. Perhaps this is the reason why safety is one feature whose satisfaction has most increased over the years analysed.

However, users have lower satisfaction (from “moderate” to “quite”) with the aspects related to environmental contamination, giving valuations of 2.7 for air quality and 2.4 for the absence of noise. Also, these valuations do not show significant differences from those registered six years ago (see Table 3). Noise was also the worst feature valuated with respect to other features analysed in Italian and Brazilian parks (Brambilla et al., 2013; Szeremeta and Zannin, 2015). In a hierarchical cluster analysis, for a rescaled distance of 10, both variables form an

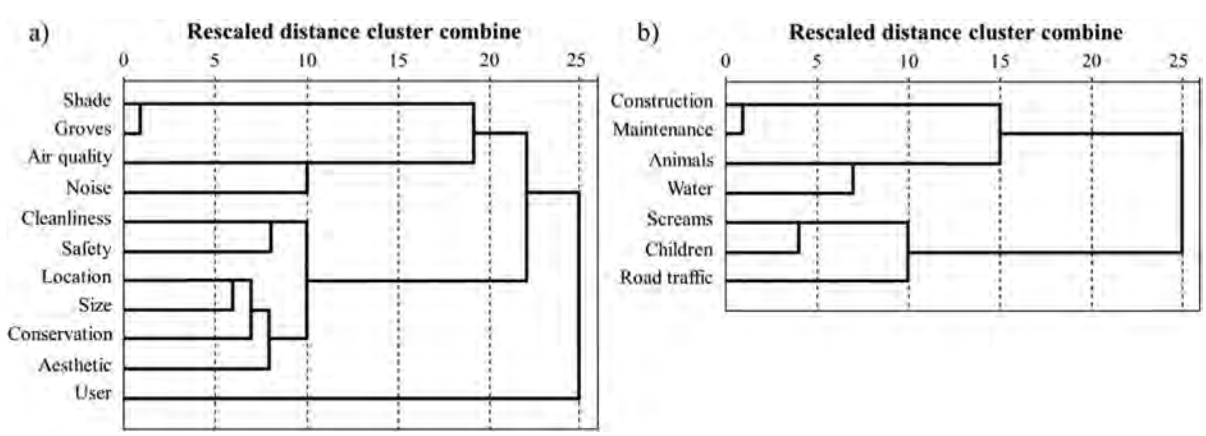

Fig. 2. Dendrograms obtained from hierarchical cluster analysis (Ward's method). The inputs to the analysis were the satisfaction with the features of urban green spaces (a) and the annoyance with the sound sources (b).

independent group [see Fig. 2(a)]. However, the mean satisfaction with the absence of noise is significantly lower than the mean satisfaction with air quality (p-value <0.01 according to the Mann-Whitney test). The fact that valuation regarding noise has not increased in the last six years, even though features such as groves have significantly increased user satisfaction, may contradict the results of other studies that show a relation between noise perception and groves (Hong and Jeon, 2013; Liu et al., 2014).

Next, the extent to which the features are considered by users of green spaces in making their overall assessments of the green space was analysed. This aspect may be important for urban planners, city leaders, and environmental engineers.

As a result of this study, all features considered have a significant influence on overall satisfaction (see Table 3). Therefore, user satisfaction with each feature of the green space contributes to increased overall satisfaction. It should be noted that the features can be ranked in descending order of intensity of correlation with the overall satisfaction as follows: noise, air quality, cleanliness, aesthetics, and conservation. Therefore, the features related to environmental pollution (noise and air quality) are those that have a greater positive correlation with respect to the overall satisfaction with the green space and, secondly, the features related to the care and design of the green space (cleaning, aesthetics, and conservation). Jeon et al. (2011) registered a higher correlation coefficient between "acoustic comfort" and "overall impression" in the largest city park in Seoul than that obtained between "visual image" and "overall impression". Also, similar results have been obtained in studies performed in urban open public spaces (Preis et al., 2015; Rey Gozalo and Barrigón Morillas, 2017; Kang and Zhang, 2010).

Moreover, an analysis of the partial correlation between the satisfaction with features and the overall satisfaction with the green space was carried out. The partial correlation coefficients obtained are shown in Fig. 3. In this partial correlation analysis, the possible influence of the other features on the bivariate correlation analysis was removed (Kim, 2015). This analysis was carried out because some features had a similar distribution with respect to the users' valuations. Therefore, users of the green spaces could be establishing relationships between the different features of green spaces. In a hierarchical cluster analysis using the Ward's method with the chi-squared measure for a rescaled distance of 10, four main groups were differentiated: air quality–noise, shade–groves, users, and other features [see Fig. 2(a)].

Fig. 3 shows that groves, safety, location, aesthetic and size do not have a significant partial correlation with the overall satisfaction and that noise is the feature that has a higher coefficient of partial correlation with the overall satisfaction with green spaces. Also, it should be noted that it has a greater influence than air quality. Perhaps the fact that satisfaction with the absence of noise has not increased since 2007–2008 influenced the fact that there is no significant variation of the overall satisfaction with the green spaces. Although the aesthetic loses the significant relation with respect to the overall satisfaction, other features related to the visual component (cleanliness and conservation) have a significant correlation coefficient. This correlation coefficient is similar to that obtained for the noise and air quality (see Fig. 3).

Then, a multivariate analysis was carried out to analyse how the set of features explains the users' overall perceptions of the urban green spaces. The results of the multinomial logistic regression are shown in Tables 4, 5, and 6. According to the likelihood ratio tests, the noise, users, conservation, and shade features contributed significantly to explaining the overall variability of the regression model (see Table 4). These features also have the highest partial correlation within each cluster [see Figs. 2(a) and 3]. The regression coefficients of these features and their significance are shown in Table 5. The values 0, 1, 2, 3 and 4 shown in Tables 5 and 6 are the values of the five-point Likert scale used in the survey where 0 is "nothing satisfied" and 4 is "very satisfied". Consequently, the visual, sound and functional aspects are included in the regression model (Liu et al., 2013). The regression model generated has a McFadden R-squared of 0.41. If the McFadden R-squared value is higher than 0.40, the multinomial logistic regression is considered to have an excellent fit quality (Pando Fernández and San Martín Fernández, 2004). There are different current survey studies that obtain similar R-squared values (De Valck et al., 2014; Lovejoy et al., 2010; Sirina et al., 2017).

Table 6 shows the practical results of using the multinomial logistic regression model. The overall percentage predicted by the multinomial logistic regression is 71.4%. The values of 2, 3, and 4 given by users for overall satisfaction constitute 97.3% of the responses. These values are predicted at 77.3, 77.9, and 63.3%, respectively, by the multivariate model (see Table 6).

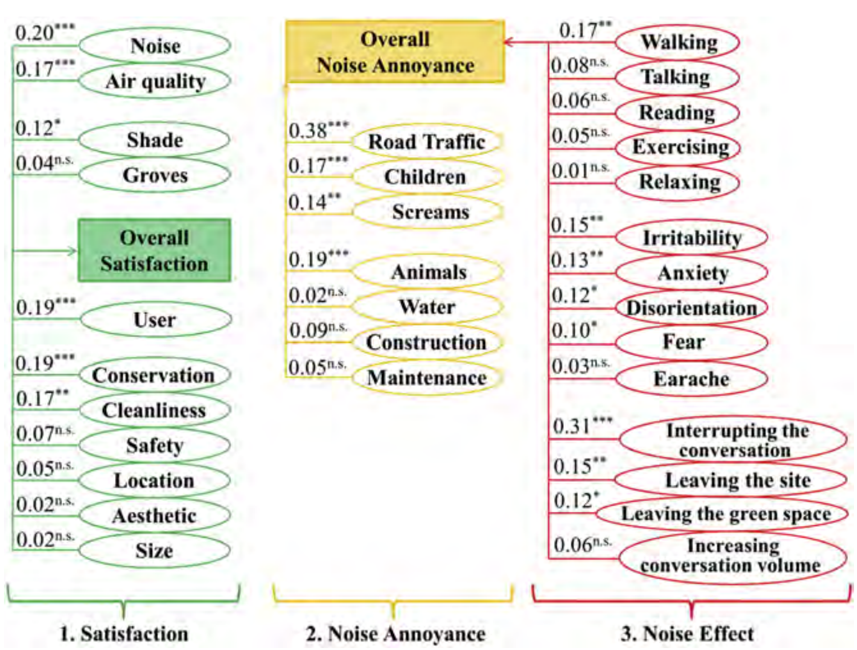

Fig. 3. Kendall's partial correlation coefficients among items of satisfaction, noise annoyance, and noise effect dimensions. * Significant at $p \leq 0.05$; ** significant at $p \leq 0.01$; *** significant at $p \leq 0.001$; n.s. non-significant correlation ($p > 0.05$).

Table 4
Likelihood ratio tests and model fitting information.

		−2 log likelihood	Chi-squared	Sig.	R-squared McFadden
Variables	Noise (1)	179.1	63.7	< 0.001	–
	Conservation (2)	157.3	41.8	< 0.001	–
	Users (3)	152.1	36.7	0.002	–
	Shade (4)	138.0	22.6	0.032	–
Model	Final (1-2-3-4)	115.5	161.1	< 0.001	0.41

The absence of noise is the environmental feature that individually has the greatest correlation with the overall satisfaction that users give to Cáceres green spaces. In addition, noise along with the conservation and shade features and the relation between users can explain 71.4% of the overall satisfaction.

3.2. Annoyance and effects of noise

The annoyance and effects of noise in Cáceres green spaces are low, as shown by the mean values in Table 7. The sound sources from road traffic and from users (screams and children) cause the most annoyance. The walking and talking activities, the emotions of fear and irritability, and the action of interrupting conversations are the most often affected by noise.

Fig. 4 shows the variability of the equivalent continuous sound level (dBA) registered in the sampling points of urban green spaces. These values are similar to the values registered in the neighbourhood streets of other Spanish cities (Rey Gozalo et al., 2013a, 2013b, 2015a). However, although road traffic was the most annoying sound source for the users of the green spaces, the degree of annoyance was lower than that estimated in neighbourhood streets (Rey Gozalo et al., 2012, 2014; Rey Gozalo and Barrigón Morillas, 2016). Also, the variability of the equivalent continuous sound level (dBA) is similar to the variability registered in the urban parks of other cities in the world (Axelsson et al., 2014; Brambilla et al., 2013; Cohen et al., 2014; Jabben et al., 2015; Lobo Soares and Bento Coelho, 2016; Szeremeta and Zannin, 2015; Tse et al., 2012).

The degree of annoyance with the different sound sources has a positive correlation with the overall noise annoyance (see Table 7). Also the overall noise annoyance has a significant correlation with the frequency of most effects caused by noise. However, although noise sensitivity has been used in recent studies as a predictor of noise annoyance and noise effects (Dzhambov and Dimitrova, 2015; Stansfeld and Shipley, 2015), its relationship with the evaluated variables has a lower correlation coefficient. In addition, noise sensitivity is not significantly correlated with some of the most annoying sources (road traffic and children) or with some of the most frequent emotions (fear). In the study by Dzhambov and Dimitrova (2015), an average annoyance higher than that found in this study was registered (a value of 5.5 on a scale of 0 to 10). Also, in the study by Stansfeld and Shipley (2015), negative health effects were more frequent than in this study. Therefore, noise sensitivity may not be a good predictor of the effects of this factor in urban environments where noise effects are low.

Thus, as in other urban environments, road traffic is the source that produces the highest degree of annoyance and has the greatest correlation coefficient with the overall annoyance. Also, the annoyance caused by the noise produced by users (children and screams) is relevant, as happens in urban environments where the traffic is restricted (Gómez Escobar et al., 2012; Barrigón Morillas et al., 2013; Rey Gozalo and Barrigón Morillas, 2017) and in public areas (Paneto et al., 2017). The most annoying sound sources form an independent cluster according to the results of the hierarchical analysis shown in Fig. 2(b). Within this cluster and removing the possible relations with the other sound sources, road traffic is the source that has a greater coefficient of partial correlation with the overall annoyance (see Fig. 3). Other sound sources, including water, animals, maintenance, and construction, rarely or never produce discomfort. Some current studies show that water sounds and ratings of soundscape quality are not directly related (Axelsson et al., 2014; Hong and Jeon, 2013). Also, although birdsong could improve the perception of the soundscape (Hong and Jeon, 2013), the predominant animal sound in Cáceres green spaces is associated with dogs barking, which has a negative effect. Thus, in the cluster formed by the animals–water–construction–maintenance sound sources [see Fig. 2(b)], annoyance with animals is the only sound source that has a significant partial correlation with the overall annoyance caused by noise (see Fig. 3).

The average annoyance with the sound sources group perceived in urban green spaces reported by the respondents is similar to the perceived annoyance with road traffic (see Table 7). Despite the low

Table 5
Parameter estimates in the multinomial logistic regression.

	Overall satisfaction[a]							
	Value = 0		Value = 1		Value = 2		Value = 3	
	B[b]	p-Value[c]	B[b]	p-Value[c]	B[b]	p-Value[c]	B[b]	p-Value[c]
Intercept	−23.3	>0.05	−55.2	>0.05	−36.7	>0.05	−2.6	<0.001
Noise = 0	17.8	>0.05	116.9	>0.05	49.5	>0.05	1.8	>0.05
Noise = 1	2.1	>0.05	44.7	>0.05	16.1	>0.05	3.3	<0.01
Noise = 2	−0.8	>0.05	54.1	>0.05	14.8	>0.05	2.3	<0.001
Noise = 3	5.1	>0.05	41.8	>0.05	−3.8	>0.05	1.5	<0.05
Noise = 4	0[d]	–	0[d]	–	0[d]	–	0[d]	–
User = 0	15.2	>0.05	0.1	>0.05	24.9	>0.05	13.4	>0.05
User = 1	1.9	>0.05	−57.1	>0.05	2.8	>0.05	2.2	<0.01
User = 2	8.9	>0.05	−15.4	>0.05	3.0	<0.05	1.3	<0.05
User = 3	0.7	>0.05	−8.9	> 0.05	1.7	>0.05	1.1	<0.05
User = 4	0[d]	–	0[d]	–	0[d]	–	0[d]	–
Conservation = 2	11.4	>0.05	65.2	>0.05	37.2	>0.05	15.4	>0.05
Conservation = 3	1.2	>0.05	−0.1	>0.05	19.2	>0.05	0.7	<0.05
Conservation = 4	0[d]	–	0[d]	–	0[d]	–	0[d]	–
Shade = 1	11.4	>0.05	16.4	>0.05	17.5	>0.05	−1.9	>0.05
Shade = 2	0.7	>0.05	−47.9	>0.05	0.7	>0.05	0.2	>0.05
Shade = 3	7.6	>0.05	−38.7	>0.05	0.5	>0.05	0.4	<0.05
Shade = 4	0[d]	–	0[d]	–	0[d]	–	0[d]	–

[a] The reference category is: 4.
[b] Regression coefficients.
[c] Wald test.
[d] This parameter is set to zero because it is redundant.

Table 6
Percentage predicted by the multinomial logistic regression.

Observed	Predicted					
	0	1	2	3	4	Percentage correct
0	0	0	0	1	0	0%
1	0	1	1	1	1	25.0%
2	0	0	17	5	0	77.3%
3	0	0	2	74	19	77.9%
4	0	0	0	22	38	63.3%
Overall percentage	0%	0.5%	11.0%	56.6%	31.9%	71.4%

value of overall annoyance (1.3 in a range of 0 to 4), this value is similar to the value registered in the old town of the same city, where road traffic is restricted (Rey Gozalo and Barrigón Morillas, 2017). The coefficient of correlation between overall annoyance and annoyance with road traffic is the highest among the sound sources analysed and this would not be significantly increased in a multivariate model. In turn, the overall annoyance is also negatively correlated with satisfaction with the absence of noise (a Kendall's bivariate correlation coefficient of − 0.26 with a p-value lower than 0.001).

Due to the low annoyance values caused by noise, low values of the frequency of effects on activities, emotions caused, and actions taken by users of green spaces to deal with the environmental noise were obtained. The values obtained ranged from 0.1 to 1.2 (see Table 7). The most affected activities are walking and talking, which coincide with the activities most frequently performed by users in green spaces (see Table 2). For this reason, the action most frequently induced among users by

Table 7
Average level of annoyance with the sound sources in urban green spaces and average level of frequency of noise effects on users. The bivariate correlation between annoyance with sound sources and the effects of noise with respect to the overall annoyance and the sensitivity of the users is also shown.

	Annoyance/frequency (scale 0–4)		Correlation with overall noise annoyance	Correlation with noise sensitivity
	Mean	Median	R^a	R^a
Sound sources				
Construction	0.4	0	0.23^{***}	0.22^{***}
Screams	1.2	1	0.40^{***}	0.17^{*}
Animals	0.9	1	0.19^{**}	$0.08^{n.s.}$
Maintenance	0.7	0	0.17^{**}	0.20^{**}
Road traffic	1.3	1	0.42^{***}	$0.07^{n.s.}$
Children	1.1	1	0.32^{***}	$0.07^{n.s.}$
Water	0.4	0	0.14^{*}	$0.12^{n.s.}$
Overall noise annoyance	1.3	1	–	0.21^{**}
Affected activities				
Talking	1.1	1	0.41^{***}	0.14^{*}
Reading	0.1	0	$0.06^{n.s.}$	$0.03^{n.s.}$
Relaxing	0.6	0	0.28^{***}	$0.12^{n.s.}$
Walking	0.8	1	0.41^{***}	0.17^{*}
Exercising	0.3	0	$0.10^{n.s.}$	$0.03^{n.s.}$
Emotions				
Irritability	0.6	0	0.36^{***}	0.32^{***}
Anxiety	0.1	0	0.16^{*}	0.24^{**}
Disorientation	0.1	0	0.19^{**}	0.19^{*}
Fear	1.1	1	0.33^{***}	$0.14^{n.s.}$
Earache	0.4	0	0.31^{***}	0.31^{***}
Actions				
Increasing conversation volume	0.3	0	$0.02^{n.s.}$	$-0.02^{n.s.}$
Interrupting the conversation	1.2	1	0.49^{***}	0.17^{*}
Leaving the site	0.5	0	0.18^{**}	0.20^{**}
Leaving the green space	0.1	0	0.17^{*}	$0.14^{n.s.}$

[n.s.] Non-significant correlation ($p > 0.05$).
[a] Correlation coefficient (Kendall's tau-b).
* Significant at $p \leq 0.05$.
** Significant at $p \leq 0.01$.
*** Significant at $p \leq 0.001$.

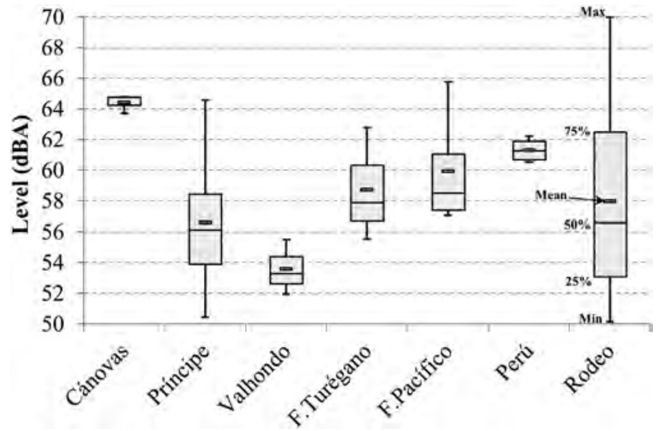

Fig. 4. Box plot of the equivalent sound level measured in the green spaces of Cáceres.

noise is interruption of conversations. Regarding users' emotions, the most frequently reported are fear and irritability. Also, the main reaction to noise exposure in Brazilian urban areas was irritability (Paneto et al., 2017). It should be noted that the activities, emotions, and actions that have a higher frequency of occurrence have a very significant correlation with the overall noise annoyance (see Table 7). In a partial correlation analysis (see Fig. 3), some of the relations would cease to be significant because of the possible relation between the effects analysed (e.g. talking). However, the higher partial correlation coefficients also coincide with the effects most frequently reported by users (see Fig. 3 and Table 7).

Then, an analysis of the relation between both the annoyance caused by noise sources and the effects caused by noise and the registered sound indicators was carried out (see Table 8). The effects caused by noise did not have a significant relationship with sound levels registered at the sampling points, except for the action of leaving the site. Table 8 shows how levels of sound indicators related to background noise (L_{A90}, L_{A95}, L_{A99}, and L_{Amin}) contribute to an increased frequency of users leaving the site. A similar result is obtained with regard to annoyance caused by water sources. Therefore, perhaps the sound level produced by water sources is not a suitable alternative way to improve the perception of sound in these green spaces. In some cases, this could be because water sounds may overlap with other natural sounds, as some studies show (Axelsson et al., 2014; Hong and Jeon, 2013). Also, the results obtained for the correlation between sharpness and the action of leaving the site or the annoyance caused by water may be interesting. Perhaps some spectral characteristics associated with this sound source, which determine the background sound level in an environment with water sources or waterfalls, may not be appropriate in green spaces or at least for certain types of activities for which they are designed.

The equivalent continuous linear weighted sound level registered with the binaural device is the only sound indicator with a significant correlation with the overall noise annoyance. In addition, this sound indicator has the highest negative correlation with noise satisfaction, although in this case, the A-weighted equivalent sound level and loudness (registered with the same device) have highly significant correlations. In recent studies (Preis et al., 2015; Rey Gozalo et al., 2015b) the equivalent sound level also explained a percentage of variability higher than some psychoacoustic indicators in the assessment of soundscape. Also, this sound indicator shows the greatest significant correlation with some of the sound sources that were perceived as the most annoying in these environments: road traffic and animals. In the case of the animal sound source coming from dogs barking, this correlation is negative. This result shows how these sound sources are sporadic and can be overlapped by other predominant sources in the environment. This result for the equivalent continuous linear weighted sound level is of great interest and may indicate the existence of effects

Table 8
Spearman's correlation coefficients among noise perception data and sound indicators.

Sound indicator	Noise annoyance				Satisfaction	Noise effects
	Animals	Road traffic	Water	Overall	Noise	Leaving the site
L_{Cpeak}	$-0.18^{n.s.}$	0.34^{*}	$0.09^{n.s.}$	$0.19^{n.s.}$	-0.33^{*}	$0.08^{n.s.}$
L_{Amax}	$-0.08^{n.s.}$	$0.24^{n.s.}$	$0.13^{n.s.}$	$0.12^{n.s.}$	$-0.23^{n.s.}$	$0.11^{n.s.}$
L_{A1}	$-0.24^{n.s.}$	0.36^{*}	$0.12^{n.s.}$	$0.02^{n.s.}$	$-0.22^{n.s.}$	$0.11^{n.s.}$
L_{A5}	$-0.28^{n.s.}$	0.35^{*}	$0.18^{n.s.}$	$0.06^{n.s.}$	$-0.29^{n.s.}$	$0.09^{n.s.}$
L_{A10}	$-0.30^{n.s.}$	0.33^{*}	$0.20^{n.s.}$	$0.04^{n.s.}$	$-0.29^{n.s.}$	$0.11^{n.s.}$
L_{A50}	$-0.32^{n.s.}$	$0.25^{n.s.}$	$0.26^{n.s.}$	$0.05^{n.s.}$	$-0.25^{n.s.}$	$0.26^{n.s.}$
L_{A90}	$-0.20^{n.s.}$	$0.12^{n.s.}$	0.37^{*}	$0.10^{n.s.}$	$-0.21^{n.s.}$	0.36^{*}
L_{A95}	$-0.18^{n.s.}$	$0.11^{n.s.}$	0.40^{*}	$0.10^{n.s.}$	$-0.20^{n.s.}$	0.37^{*}
L_{A99}	$-0.16^{n.s.}$	$0.10^{n.s.}$	0.42^{*}	$0.10^{n.s.}$	$-0.19^{n.s.}$	0.38^{*}
L_{Amin}	$-0.10^{n.s.}$	$0.08^{n.s.}$	0.45^{**}	$0.09^{n.s.}$	$-0.19^{n.s.}$	0.40^{*}
L_{Aeq}	$-0.27^{n.s.}$	$0.29^{n.s.}$	$0.24^{n.s.}$	$0.01^{n.s.}$	$-0.26^{n.s.}$	$0.23^{n.s.}$
$L_{eq}{}^{b}$	-0.42^{*}	0.60^{***}	$0.09^{n.s.}$	0.35^{*}	-0.63^{***}	$0.10^{n.s.}$
$L_{Aeq}{}^{b}$	$-0.24^{n.s.}$	$0.32^{n.s.}$	$0.23^{n.s.}$	$0.16^{n.s.}$	-0.50^{**}	$0.21^{n.s.}$
Loudness[b]	$-0.20^{n.s.}$	$0.33^{n.s.}$	$0.25^{n.s.}$	$0.18^{n.s.}$	-0.52^{**}	$0.27^{n.s.}$
Sharpness[b]	$-0.03^{n.s.}$	$0.10^{n.s.}$	0.47^{**}	$0.17^{n.s.}$	$-0.09^{n.s.}$	0.48^{**}

n.s. Non-significant correlation ($p > 0.05$).
* Significant at $p \leq 0.05$.
** Significant at $p \leq 0.01$.
*** Significant at $p \leq 0.001$.
b Registered with a binaural device.

associated with the sound spectrum, which are minimized to some extent when the A-weighted equivalent sound level is taken as reference for evaluating the acoustic situation of an environment. This reasoning, which considers the spectral characteristics of a sound environment to be relevant to perception of it, has also been presented with respect to sharpness in the previous paragraph. In Table 8, the sharpness or L_{eq} (dB) has the highest value of the correlation coefficient in relation to the aspects studied. Therefore, this result may indicate that the sound spectrum can be of great importance in environments with low sound levels and, consequently with low levels of noise effects, if we wish to improve the features of the soundscape.

3.3. Sociodemographic characteristics, use of green spaces, and perception of environment

Study of the relationships between sociodemographic characteristics and the perception of the features of urban environments could explain a certain percentage of their variability that cannot be explained by physical variables. However, there is no clear trend in the significance of the relations between these variables (Yu and Kang, 2008). Generally, gender has no significant effects on sound perception (Kang and Zhang, 2010). This result is similar to that obtained in this study except for the annoyance with the sound source coming from children (see Table 9). It is frequently women who take children to green spaces (see Table 10), and because of the proximity to this sound source, it is women who experience greater annoyance. Therefore, this significant difference between genders is caused by the use of the green space.

Age, level of education, and work activity tend to have significant relations with noise perception (Yu and Kang, 2008). Table 9 shows that older people have lower satisfaction with some features of green spaces and higher annoyance with some sound sources. Also, as shown by recent studies (Dadvand et al., 2016; Dzhambov and Dimitrova, 2015), there is a positive correlation between age and the frequency of noise effects and, in some cases, this correlation is very significant ($p < 0.001$). In addition, age is related to significant differences in work activity, because it is retirees who have the worst perceptions of the features of green spaces and the noise in them.

Educational level has a positive correlation with satisfaction with the features of green spaces and a negative correlation with annoyance and effects of noise. This result differs from the results obtained in other studies, in which people with a higher education level felt slightly more annoyed (Miedema and Vos, 1999). This difference can be explained by the correlation between the educational level and the uses of the green space (see Table 10). It can be seen that people with a higher educational level use the green space for exercise more frequently and the users who perform physical activity in the green space indicate that they are annoyed or affected by the noise in the green space with lower frequency, as shown in Table 9.

Next, the relationships between the frequency of the type of use by users and their perceptions of the features of the green space and the existing noise are analysed. The results of these relationships may be relevant for designing a green space for certain uses.

It is interesting to point out that the users who most frequently perform a certain activity in the green space also indicate that noise affects them more frequently. Thus, users who perform an activity more frequently show a greater sensitivity to noise.

Reading and relaxing are activities that need quiet environments for good development. In addition, relaxing is an important activity to ease the stress to which the inhabitants of current cities are submitted. There are numerous studies that relate stress to serious health problems (Agyei et al., 2014; Grazuleviciene et al., 2017; Harris et al., 2017). Hence the existence of green areas that are properly designed for carrying out this activity is important. Users who most frequently perform relaxing and reading activities have significant correlations with those who indicate that noise frequently affects reading and relaxation activities, respectively. However, perhaps because of the low percentage of users who read in Cáceres green spaces (see Table 2), only users who frequently go there to relax show significant relationships with the features of the green space. They have a positive correlation with satisfaction with air quality, absence of noise, aesthetics, users, shade, and groves (see Table 9) and a negative correlation with the registered sound values (see Table 11). Therefore, the quality of all these features and the presence of low sound levels should be considered in the design of green spaces to allow relaxing activities to carry out properly. Sound indicators related to background noise and to a high-frequency spectral composition are those without a significant correlation with the frequency of use of relaxation activity (see Table 11). However, sound indicators related to high-intensity sources have a significant correlation. Considering the complete area of green spaces, these sound sources will correspond to road traffic or to animals, in particular to dogs barking. In addition, the annoyance with these sound sources is positively correlated with users who frequently go to green spaces to relax and read (see Table 9).

As previously mentioned, children are most frequently taken to green spaces by women and their annoyance with the sound source arising from children is significantly greater than that of men. Also,

Table 9
Relationships among sociodemographic characteristics, green-space use, and satisfaction with the features, noise annoyance, and effects of noise in urban green spaces.

	Sociodemographic characteristics				Urban green space use							
	Age	Sex	Education	Work activity	Reading	Taking children out	Relaxing	Exercising	Walking	Talking	Daily duration	Years visiting the park
	R[a]	X^2[b]	R[a]	X^2[b]	R[a]							
Satisfaction												
Cleanliness	−0.21***	–	0.19**	9.7*	–	–	–	–	–	–	–	–
Air quality	–	–	–	–	–	–	0.26***	–	–	–	–	–
Noise	–	–	–	–	–	–	0.19**	–	–	–	–	–
Aesthetic	–	–	–	–	–	–	0.18**	–	–	–	–	–
Safety	−0.24***	–	–	17.8**	–	–	−0.19**	–	–	–	−0.20**	−0.31***
User	–	–	–	–	–	0.15*	0.16*	−0.40***	0.22***	0.55***	0.23***	–
Conservation	–	–	–	–	–	–	–	–	–	–	–	–
Location	–	–	–	–	–	0.18*	–	–	–	–	–	–
Size	–	–	–	–	–	–	–	0.16*	–	–	–	–
Shade	–	–	–	12.2*	–	–	0.22***	0.21**	–	–	–	–
Groves	–	–	–	11.9*	–	–	0.19**	0.25***	–	–	–	–
All features	−0.30***	–	0.14*	14.2**	–	–	–	–	–	–	–	–
Sound sources annoyance												
Construction	0.24***	–	−0.14*	–	–	–	–	–	–	–	0.31***	0.16*
Screams	0.17**	–	–	–	–	–	–	−0.19**	–	0.17**	0.20**	–
Animals	–	–	−0.24***	–	0.15*	–	0.21***	–	0.22***	0.14*	–	–
Maintenance	0.29***	–	–	28.8**	–	–	–	–	0.14*	–	0.21***	–
Road traffic	–	–	–	–	0.19**	–	0.19**	−0.15*	–	–	–	–
Children	0.15**	9.6*	–	–	–	0.29***	–	−0.16*	0.16*	0.17**	0.12*	0.20**
Water	–	–	–	–	–	–	–	−0.15*	–	–	–	–
Overall	0.28***	–	−0.16**	30.1*	–	–	0.15*	−0.21**	0.16**	–	0.12*	–
Frequency affected activities												
Talking	0.19***	–	−0.19**	18.8***	–	–	–	−0.34**	0.24***	0.38***	0.17**	0.25***
Reading	–	–	–		0.84***	–	0.17*	–	–	–	–	0.21**
Relaxing	–	–	–		0.19**	–	0.20**	−0.14*	0.17**	0.14*	–	0.18**
Walking	0.31***	–	−0.26***	22.7***	–	–	0.15*	−0.23***	0.25***	0.20**	0.25***	–
Exercising	0.28***	–	−0.19**	24.9***	–	–	–	0.62***	−0.30***	−0.47***	–	−0.21**
Frequency emotions												
Irritability	0.23***	–	–	–	–	–	–	−0.26***	–	–	0.21***	0.16*
Anxiety	0.22***	–	−0.13*	12.5*	0.18*	–	0.14*	–	0.15*	–	0.22***	–
Disorientation	0.13*	–	–	–	0.19*	–	–	–	0.16*	–	–	–
Fear	0.18**	–	−0.17**	21.8***	–	–	–	−0.26***	–	0.15*	–	–
Earache	0.30***	–	–	20.3***	–	–	–	−0.20**	–	–	0.21***	0.18**
Frequency actions												
Increasing conversation volume	0.22***	–	−0.17**	18.7***	–	–	–	−0.36***	0.18**	−0.23**	–	–
Interrupting the conversation	0.21***	–	−0.21***	17.8**	–	–	–	−0.22***	0.20**	0.22**	0.16*	–
Leaving the site	–	–	–	–	0.22**	–	0.17**	–	0.18**	–	0.19**	0.25***
Leaving the green space	0.17**	–	–	–	–	–	–	–	0.14*	–	0.16*	–

– Non-significant correlation ($p > 0.05$).
[a] Correlation coefficient (Kendall's tau–b).
[b] Chi-squared test.
* Significant at $p < 0.05$.
** Significant at $p < 0.01$.
*** Significant at $p < 0.001$.

those who frequently take children to green spaces are positively correlated with satisfaction with the other green space users and the location of green spaces. The location of green spaces is important for those who frequently take children because they cannot walk long distances. Also, an adequate relationship with other users is important for this activity.

The frequency of the activity of speaking has a positive correlation with user satisfaction because of the importance of the presence of other users. People who perform this activity in green spaces have positive correlations with the degree of annoyance with sound sources: screams, animals, and children. Also the frequency of this activity is positively correlated with some of the most frequent effects of noise: talking, walking, feeling afraid, and interrupting the conversation.

With respect to the temporality data (number of years for which the user has visited the green space and daily frequency), there is a relation with age or work activity (retired). Therefore, some correlation results obtained in Table 9 are explained. However, it is important to highlight that daytime has a significant positive correlation with the overall annoyance with noise and with some of the effects of the higher-frequency noise.

Nowadays, cities around the world are also investing in urban green spaces to increase the physical activity of citizens (Shanahan et al., 2016; Szeremeta and Zannin, 2013). This is ever more important because a sedentary lifestyle has become increasingly prevalent in the twenty-first century. The main physical activities carried out by users of Cáceres green spaces are running and walking. In addition, these urban green spaces have outdoor gyms. Users who frequently use green spaces to exercise have positive correlations with the satisfaction with size, shade, and groves. These features benefit the development of running activity, which is the main exercise performed by users. However, these users have a negative correlation with user satisfaction. In that sense, the fact that these environments do not have specific circuits allowing users to run far away from other users may have an influence. A very relevant aspect is that users who frequently perform exercise have a negative correlation with the perception of the annoyance and

Table 10
Relationships between sociodemographic characteristics and frequency of the type of use of green spaces.

Urban green space use	Sociodemographic characteristics			
	Age	Sex	Education	Work activity
	R[a]	X^2[b]	R[a]	X^2[b]
Reading	–	–	–	–
Taking children out	–	12.9***	–	23.1***
Relaxing	0.14*	–	−0.29***	21.6***
Exercising	−0.22***	11.9***	0.24***	17.3**
Walking	0.32***	–	−0.29***	35.9***
Talking	0.14*	–	−0.29***	32.3***
Daily duration	–	–	−0.13*	23.8***
Years visiting the park	0.39***	–	−0.23***	29.4***

– Non-significant correlation ($p > 0.05$).
[a] Correlation coefficient (Kendall's tau–b).
[b] Chi-squared test.
* Significant at $p < 0.05$.
** Significant at $p < 0.01$.
*** Significant at $p < 0.001$.

effects of noise. Therefore, noise is not perceived negatively by these users. However, walking activity has a positive correlation with the annoyance with sound sources and the frequency of noise effects except for sports. Users who frequently go to green spaces to walk, as well as those who go to relax, have a significant correlation with the overall annoyance with noise sources. In fact, users who walk avoid places with high sound levels in terms of L_{Aeq} (indicator represented in noise maps) and the statistical sound indicators L_{A1}, L_{A5}, and L_{A10}, which are related to discontinuous and intense sound sources, as shown in Table 11. Walking activity generates health benefits and improves the quality of life (Liu et al., 2017). In fact, sustainable urban design uses the “walkability” concept. In this study, walking frequency has a positive correlation with the age of the users and also a significant difference in the case of retirees (see Table 10). Regular performance of walking activity in old age effectively prevents the onset and development of chronic diseases and helps maintain a good quality of life (Ikenaga et al., 2017; Van Cauwenberg et al., 2016). This is important as the population of older adults is rapidly growing worldwide. Therefore, noise is a factor that should be considered in the design of green spaces.

Table 11
Spearman's correlation coefficients among green space use data and sound indicators at the sampling point.

Sound indicator	Urban green space use	
	Relaxing	Walking
L_{Cpeak}	−0.52**	−0.07[n.s]
L_{Amax}	−0.41*	−0.29[n.s]
L_{A1}	−0.53***	−0.41*
L_{A5}	−0.54***	−0.38*
L_{A10}	−0.51**	−0.34*
L_{A50}	−0.42*	−0.30[n.s]
L_{A90}	−0.25[n.s.]	−0.24[n.s]
L_{A95}	−0.24[n.s.]	−0.24[n.s]
L_{A99}	−0.22[n.s.]	−0.23[n.s]
L_{Amin}	−0.17[n.s.]	−0.19[n.s]
L_{Aeq}	−0.45**	−0.33*
L_{eq}[b]	−0.74***	−0.25[n.s]
L_{Aeq}[b]	−0.50**	−0.10[n.s]
Loudness[b]	−0.47**	−0.12[n.s]
Sharpness[b]	−0.02[n.s.]	−0.15[n.s]

[n.s.]Non-significant correlation ($p > 0.05$).
* Significant at $p \leq 0.05$.
** Significant at $p \leq 0.01$.
*** Significant at $p \leq 0.001$.
[b] Registered with a binaural device.

4. Conclusions

The analysis of urban green spaces is important for their management and future design. These areas need to be conserved and/or improved due to the social, environmental, and economic functions they have in the urban environment. A study was carried out in Cáceres green spaces by means of surveys and sound measurements. The analysis of user satisfaction with the features of urban green spaces leads to the following conclusions:

- Users show satisfaction levels of “quite satisfied” to “very satisfied” with regard to the features of green spaces except for the aspects related to environmental contamination such as air quality and noise. These environmental features have the highest significant relationship with the overall satisfaction with the green space.
- Noise satisfaction is the only studied feature of green spaces that has not increased in the last six years. That fact could be the reason why the increase in overall satisfaction with green spaces over these years is not significant.
- Together with the satisfaction with other users, conservation, and shade, noise satisfaction correctly predicts 71.4% of the variability of overall satisfaction with green spaces.

The importance that users gave to noise satisfaction in the overall satisfaction with green spaces was the reason for carrying out an analysis of the contribution of sound sources to the perception of the sound environment and the study of its possible effects. The analysis yielded the following conclusions:

- Noise sources in Cáceres green spaces produce a low level of annoyance among the users, below that estimated in other urban areas with a similar level of sound exposure. Also, as in other urban areas, road traffic is the most annoying sound source and is also the sound source with the most significant correlation with both overall annoyance and the registered sound indicators.
- As happens with the annoyance with noise sources, noise effects are low. The activities of talking and walking, emotions of fear and irritability, and the action of interrupting the conversation are most frequently affected by noise. Also, these effects have the highest significant correlation with the overall annoyance.
- The equivalent continuous sound level (dB) and sharpness (acum) have a greater significant correlation with the perception of noise by users. Therefore, this result may indicate the importance of the sound spectrum for the improvement of the features of the sound landscape in environments with low sound levels and consequently low noise effects.

Finally, when relating the perception of the environment with sociodemographic characteristics and the use of green spaces, the following conclusions emerge:

- The type of use of green spaces shows significant differences according to gender and education level. Women take children to green spaces more often than men and users with a higher educational level have a significant relation with greater frequency of exercising in green spaces. These differences influence the perception of sound sources. Women show higher annoyance with the sound source coming from children, and educational level has a negative correlation with the perception of noise.
- The activities of running, relaxing, and walking are essential to decrease health problems associated with stress and a sedentary lifestyle among the population. In this study, three conclusions can be drawn:

• Size, shade, and groves benefit running activity, but noise is not a relevant factor. However, the negative correlation between running activity and user satisfaction indicates the need for these environments to have specific circuits for running far away from the influence of other users.

- Walking activity is the most frequent use of green spaces. The sites in green spaces with high noise levels show a significant decrease in the frequency of walking activity. Therefore, noise is a fundamental factor that should be considered in the design of green spaces in which this activity is properly developed.
- Air quality, shade, groves, the absence of noise, and aesthetics are significantly related to the frequency with which users go to green spaces to relax. Also, relaxation activity has a high correlation with noise level, especially with L_{eq} (dB). Consequently, if urban green spaces must have a relaxation function, their design should consider noise as an essential factor.

References

Agyei, B., Nicolaou, M., Boateng, L., Dijshoorn, H., Van Den Born, B.-J., Agyemang, C., 2014. Relationship between psychosocial stress and hypertension among Ghanaianans in Amsterdam, the Netherlands – the GHAIA study. BMC Public Health 14 (1), 692.

Aldenderfer, M.S., Blashfield, R.K., 1984. Cluster analysis. Sage University Papers Series: Quantitative Applications in the Social Sciences. Sage Publications, California.

Alvey, A.A., 2006. Promoting and preserving biodiversity in the urban forest. Urban For. Urban Green. 5, 195–201.

Axelsson, Ö., Nilsson, M.E., Hellström, B., Lundén, P., 2014. A field experiment on the impact of sounds from a jet-and-basin fountain on soundscape quality in an urban park. Landsc. Urban Plan. 123, 49–60.

Barrigón Morillas, J.M., Gómez Escobar, V., Rey Gozalo, G., 2013. Noise source analyses in the acoustical environment of the medieval centre of Cáceres (Spain). Appl. Acoust. 74, 526–534.

Barrigón Morillas, J.M., Montes González, D., Rey Gozalo, G., 2016. A review of the measurement procedure of the ISO 1996 standard. Relationship with the European Noise Directive. Sci. Total Environ. 565, 595–606.

Benfield, J.A., Bell, P.A., Troup, L.J., Soderstrom, N.C., 2010. Aesthetic and affective effects of vocal and traffic noise on natural landscape assessment. J. Environ. Psychol. 30, 103–111.

Brambilla, G., Gallo, V., Zambon, G., 2013. The soundscape quality in some urban parks in Milan, Italy. Int. J. Environ. Res. Public Health 10, 2348–2369.

Brebbia, C.A., Hernández, S., Tiezzi, E., 2010. The Sustainable City VI: Urban Regeneration and Sustainability. WIT Press, Southhampton.

Carles, J.L., López Barrios, I., de Lucio, J.V., 1999. Sound influence on landscape values. Landsc. Urban Plan. 43, 191–200.

Chiesura, A., 2011. The role of urban parks for the sustainable city. Landsc. Urban Plan. 68, 129–138.

Cohen, P., Potchter, O., Schnell, I., 2014. The impact of an urban park on air pollution and noise levels in the Mediterranean city of Tel-Aviv, Israel. Environ. Pollut. 195, 73–83.

Coombes, E., Jones, A.P., Hillsdon, M., 2010. The relationship of physical activity and overweight to objectively measured greenspace accessibility and use. Soc. Sci. Med. 70, 816–822.

Dadvand, P., Bartoll, X., Basagaña, X., Dalmau-Bueno, A., Martinez, D., Ambros, A., Cirach, M., Triguero-Mas, M., Gascon, M., Borrell, C., Nieuwenhuijsen, M.J., 2016. Green spaces and general health: roles of mental health status, social support, and physical activity. Environ. Int. 91, 161–167.

De Valck, J., Vlaeminck, P., Broekx, S., Liekens, I., Aertsens, J., Chen, W., Vranken, L., 2014. Benefits of clearing forest plantations to restore nature? Evidence from a discrete choice experiment in Flanders, Belgium. Landsc. Urban Plan. 125, 65–75.

Doick, K.J., Peace, A., Hutchings, T.R., 2014. The role of one large greenspace in mitigating London's nocturnal urban heat island. Sci. Total Environ. 493, 662–671.

Dzhambov, A.M., Dimitrova, D.D., 2015. Green spaces and environmental noise perception. Urban For. Urban Green. 14, 1000–1008.

EC (European Commission), 2000. Towards a Local Sustainability Profile: European Common Indicators. Office for Official Publications of the European Communities, Luxembourg.

EC (European Commission), 2002. Directive 2002/49/EC Relating to the Assessment and Management of Environmental Noise. Offic J Euro Commun L 189, 12–26. European Commission, Brussels, Belgium.

EEA (European Environment Agency), 2014. Noise in Europe 2014. Publications Office of the European Union, Luxembourg.

EEA (European Environment Agency), 2016. Atmospheric Greenhouse Gas Concentrations. European Environment Agency, Copenhagen.

Feyisa, G.L., Dons, K., Meilby, H., 2014. Efficiency of parks in mitigating urban heat island effect: an example from Addis Ababa. Landsc. Urban Plan. 123, 87–95.

Fritz, M.S., Mackinnon, D.P., 2007. Required sample size to detect the mediated effect. Psychol. Sci. 18, 233–239.

Gómez Escobar, V., Barrigón Morillas, J.M., Rey Gozalo, G., Vaquero, J., Méndez Sierra, J.A., Vílchez-Gómez, R., Carmona del Río, F.J., 2012. Acoustical environmental of the medieval centre of Cáceres (Spain). Appl. Acoust. 73, 673–685.

Grahn, P., Stigsdotter, U.A., 2003. Landscape planning and stress. Urban For. Urban Green. 2, 1–18.

Grahn, P., Stigsdotter, U.A., 2010. The relation between perceived sensory dimensions of urban green space and stress restoration. Landsc. Urban Plan. 94, 264–275.

Grazuleviciene, R., Petraviciene, I., Andrusaityte, S., Balseviciene, B., 2017. Psychosocial stress and obesity among children residing in Kaunas City. Environ. Res. 157, 37–43.

Greenacre, M.J., 1988. Clustering the rows and columns of a contingency table. J. Classif. 5, 39–51.

Harris, M.L., Oldmeadow, C., Hure, A., Luu, J., Loxton, D., Attia, J., 2017. Stress increases the risk of type 2 diabetes onset in women: a 12-year longitudinal study using causal modelling. PLoS One 12 (2), e0172126.

Hong, J.Y., Jeon, J.Y., 2013. Designing sound and visual components for enhancement of urban soundscapes. J. Acoust. Soc. Am. 134, 2026–2036.

Hussain, T., Asghar, S., 2016. Chi-square based hierarchical agglomerative clustering for web sessionization. J. Natl. Sci. Found. Sri 44, 211–222.

IEAGHG (International Energy Agency Greenhouse Gas), 2016. Information Paper 2016-IP10 CCAC Annual Science Update 2015. International Energy Agency Greenhouse Gas, Cheltenham.

Ikenaga, M., Yamada, Y., Kose, Y., Morimura, K., Higaki, Y., Kiyonoga, A., Tanaka, H., Nakagawa Study Group, 2017. Effects of a 12-week, short-interval, intermittent, low-intensity, solw-jogging program on skeletal muscle, fat infiltration, and fitness in older adults: randomized controlled trial. Eur. J. Appl. Physiol. 117, 7–15.

INE (Instituto Nacional de Estadística), 2015. Censo de Población y Viviendas. Instituto Nacional de Estadística, Madrid.

ISO 1996-2, 2007. Acoustics — Description, Measurement and Assessment of Environmental Noise. Part 2: Determination of Environmental Noise Levels. International Organization for Standardization, Geneva, Switzerland.

Jabben, J., Weber, M., Verheijen, E., 2015. A framework for rating environmental value of urban parks. Sci. Total Environ. 508, 395–401.

Jay, M., Schraml, U., 2009. Understanding the role of urban forests for migrants– uses, perception and integrative potential. Urban For. Urban Green. 8, 283–294.

Jeon, J.Y., Lee, P.J., Hong, J.Y., 2011. Non-auditory factors affecting urban soundscape evaluation. J. Acoust. Soc. Am. 130, 3761–3770.

Jeon, J.Y., Hong, J.Y., Lee, P.J., 2013. Soundwalk approach to identify urban soundscapes individually. J. Acoust. Soc. Am. 134, 803–812.

Jim, C.Y., Chen, W.Y., 2006. Recreation – amenity use and contingent valuation of urban Greens-paces in Guangzhou, China. Landsc. Urban Plan. 75, 81–96.

Kaczynski, A.T., Potwarka, L.R., Saelens, B.E., 2008. Association of park size, distance, and features with physical activity in neighbourhood parks. Am. J. Public Health 98, 1451–1456.

Kang, J., Zhang, M., 2010. Semantic differential analysis of the soundscape in urban open public spaces. Build. Environ. 45, 150–157.

Kim, S., 2015. ppcor: an R package for a fast calculation to semi-partial correlation coefficients. Commun. Stat. Appl. Methods 22, 665–674.

Kuiper, F.K., Fisher, L., 1975. A Monte Carlo comparison of six clustering procedures. Biometrics 31, 777–783.

Lam, K.C., Ng, S.L., Hui, W.C., Chan, P.K., 2005. Environmental quality of urban parks and open spaces in Hong Kong. Environ. Monit. Assess. 111, 55–73.

Liu, J., Kang, J., Luo, T., Behm, H., 2013. Landscape effects on soundscape experience in city parks. Sci. Total Environ. 454–455, 474–481.

Liu, J., Kang, J., Behm, H., Luo, T., 2014. Effects of landscape on soundscape perception: soundwalks in city parks. Landsc. Urban Plan. 123, 30–40.

Liu, H., Li, F., Li, J., Zhang, Y., 2017. The relationships between urban parks, residents' physical activity, and mental health benefits: A case study from Beijing, China. J. Environ. Manag. 190, 223–230.

Lobo Soares, A.C., Bento Coelho, L.B., 2016. Urban parks soundscape in distinct sociocultural and geographical context. Noise Mapp. 3, 232–246.

López Barrios, I., 2001. El Significado del Medio Ambiente Sonoro en el Entorno Urbano. Estud. Geol. 62, 447–466.

Lovejoy, K., Handy, S., Mokhtarian, P., 2010. Neighborhood satisfaction in suburban versus traditional environments: an evaluation of contributing characteristics in eight California neighborhoods. Landsc. Urban Plan. 97, 37–48.

Luttik, J., 2000. The value of trees, water and open spaces as reflected by house prices in the Netherlands. Landsc. Urban Plan. 48, 161–167.

Maas, J., van Dillen, S.M.E., Verheij, R.A., Groenewegen, P.P., 2009. Social contacts as a possible mechanism behind the relation between greenspace and health. Health Place 15, 586–595.

Martínez Suárez, P., Moreno Jiménez, A., 2013. Noise and quietness in Madrid parks (Spain): a GIS based environmental case analysis. An. Geograf. 33, 133–160.

Miedema, H.M.E., Vos, H., 1999. Demographic and attitudinal factors that modify annoyance from transportation noise. J. Acoust. Soc. Am. 105, 3336–3344.

Murtagh, F., Legendre, P., 2014. Ward's hierarchical agglomerative clustering method: which algorithms implement Ward's criterion? J. Classif. 31, 274–295.

Nilsson, M.E., Berglund, B., 2006. Soundscape quality in suburban green areas and city parks. Acta Acust. United Acust. 92, 903–911.

Paker, Y., Yom-Tox, Y., Alon-Mozes, T., Barrnea, A., 2014. The effects of plant richness and urban garden structure on bird species richness, diversity, and community structure. Landsc. Urban Plan. 122, 186–195.

Pando Fernández, V., San Martín Fernández, R., 2004. Regresión logística multinomial. Cuad. Soc. Esp. Cien. For. 18, 323–327.

Paneto, G.G., de Alvarez, C.E., Zannin, P.H.T., 2017. Relationship between urban noise and the health of users of public spaces – a case study in Vitoria, ES, Brazil. J. Build. Constr. Plann. Res. 5, 45–57.

Peters, K., Elands, B., Buijs, A., 2010. Social interactions in urban parks: stimulating social cohesion? Urban For. Urban Green. 9, 93–100.

Preis, A., Kociński, J., Hafke-Dys, H., Wrzosek, M., 2015. Audio-visual interactions in environment assessment. Sci. Total Environ. 523, 191–200.

Rey Gozalo, G., Barrigón Morillas, J.M., 2016. Analysis of sampling methodologies for noise pollution assessment and the impact on the population. Int. J. Environ. Res. Public Health 13, 490.

Rey Gozalo, G., Barrigón Morillas, J.M., 2017. Perceptions and effects of the acoustic environment in quiet residential areas. J. Acoust. Soc. Am. 141, 2418–2429.

Rey Gozalo, G., Barrigón Morillas, J.M., Gómez Escobar, V., 2012. Analysis of noise exposure in two small towns. Acta Acust. United Acust. 98, 884–893.

Rey Gozalo, G., Barrigón Morillas, J.M., Gómez Escobar, V., 2013a. Urban streets functionality as a tool for urban pollution management. Sci. Total Environ. 461–462, 453–461.

Rey Gozalo, G., Barrigón Morillas, J.M., Gómez Escobar, V., Vílchez-Gómez, R., Méndez Sierra, J.A., Carmona del Río, F.J., Prieto Gajardo, C., 2013b. Study of the categorisation method using long-term measurements. Arch. Acoust. 38, 397–405.

Rey Gozalo, G., Barrigón Morillas, J.M., Gómez Escobar, V., 2014. Analyzing nocturnal noise stratification. Sci. Total Environ. 479–480, 39–47.

Rey Gozalo, G., Barrigón Morillas, J.M., Prieto Gajardo, C., 2015a. Urban noise functional stratification for estimating average annual sound level. J. Acoust. Soc. Am. 137, 3198–3208.

Rey Gozalo, G., Trujillo Carmona, J., Barrigón Morillas, J.M., Vílchez-Gómez, R., Gómez Escobar, V., 2015b. Relationship between objective acoustic indices and subjective assessments for the quality of soundscapes. Appl. Acoust. 97, 1–10.

RFSC, 2016. 5 Dimensions and 30 Objectives for a European Vision of Tomorrow's Cities. The Reference Framework for Sustainable Cities. http://rfsc.eu/.

Sander, H.A., 2015. Assessing impacts on urban greenspace, waterways, and vegetation in urban planning. J. Environ. Plann. Man 59, 461–479.

Sander, H.A., Haight, R.G., 2012. Estimating the economic value of cultural ecosystem services in an urbanizing area using hedonic pricing. J. Environ. Manag. 113, 194–205.

Scopelliti, M., Carrus, G., Adinolfi, C., Suarez, G., Colangelo, G., Lafortezza, R., Panno, A., Sanesi, G., 2016. Staying in touch with nature and well-being in different income groups: the experience of urban parks in Bogotá. Landsc. Urban Plan. 148, 139–148.

Shanahan, D.F., Franco, L., Lin, B.B., Gaston, K.J., Fuller, R.A., 2016. The benefits of natural environments for physical activity. Sports Med. 46, 989–995.

Shen, Y.-S., Candice Lung, S.-C., 2016. Can green structure reduce the mortality of cardiovascular diseases? Sci. Total Environ. 566–567, 1159–1167.

Sirina, N., Hua, A., Gobert, J., 2017. What factors influence the value of an urban park within a medium-sized French conurbation? Urban For. Urban Green. 24, 45–54.

Stansfeld, S.A., Shipley, M., 2015. Noise sensitivity and future risk of illness and mortality. Sci. Total Environ. 520, 114–119.

Szeremeta, B., Zannin, P.H.T., 2009. Analysis and evaluation of soundscapes in public parks through interviews and measurement of noise. Sci. Total Environ. 407, 6143–6149.

Szeremeta, B., Zannin, P.H.T., 2013. The importance of urban parks and green areas in improving the quality of life in cities (in Portuguese: A importância dos parques urbanos e áreas verdes da promoção da qualidade de vida em cidades). RA'E GA: O Espaço Geográfico em Análise 29, 177–193.

Szeremeta, B., Zannin, P.H.T., 2015. Physical activity practitioners' perception about the environmental sound quality of public parks in Curitiba, Paraná (in Portuguese: a percepção dos praticantes de actividade física sobre a qualidade ambiental sonora dos parques públicos de Curitiba – Paraná). RA'E GA: O Espaço Geográfico em Análise 33, 7–43.

Torija, A.J., Ruiz, D.P., Ramos-Ridao, A.F., 2014. A tool for urban soundscape evaluation applying Support Vector Machines for developing a soundscape classification model. Sci. Total Environ. 482–483, 440–451.

Tse, M.S., Chau, C.K., Choy, Y.S., Tsui, W.K., Chan, C.N., Tang, S.K., 2012. Perception of urban park soundscape. J. Acoust. Soc. Am. 131, 2762–2771.

UN (United Nations), 2014. World Urbanization Prospects: The 2014 Revision. United Nations, Department of Economic and Social Affairs, Population Division, New York.

Van Cauwenberg, J., Van Holle, V., De Bourdeaudhuij, I., Van Dyck, D., Deforche, B., 2016. Neighborhood walkability and health outcomes among older adults: the mediating role of physical activity. Health Place 37, 16–25.

WHO (World Health Organization), 2011. Burden of Disease from Environmental Noise. Quantification of Healthy Life Years Lost in Europe. World Health Organization Regional Office for Europe, Denmark.

WHO (World Health Organization), 2014. Burden of Disease from Household Air Pollution for 2012. World Health Organization, Geneva.

Xiao, Q., McPherson, E.G., Simpson, J.R., Ustin, S.L., 1998. Rainfall interception by sacramento's urban forest. J. Arboric. 24, 235–244.

Yin, S., Shen, Z., Zhou, P., Zou, X., Che, S., Wang, W., 2011. Quantifying air pollution attenuation within urban parks: an experimental approach in Shanghai, China. Environ. Pollut. 159, 2155–2163.

Yu, L., Kang, J., 2008. Effects of social, demographical and behavioral factors on the sound level evaluation in urban open spaces. J. Acoust. Soc. Am. 123, 772–783.

Yu, C.-J., Kang, J., 2014. Soundscape in the sustainable living environment: a cross-cultural comparison between the UK and Taiwan. Sci. Total Environ. 482–483, 501–509.

Zannin, P.H., Ferreira, A.M., Szeremeta, B., 2006. Evaluation of noise pollution in urban parks. Environ. Monit. Assess. 118, 423–433.