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Attractiveness of urban parks for visitors versus their potential allergenic hazard: A case study in Rzeszów, Poland

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ABSTRACT

The political and social changes that have taken place in Central Europe after the collapse of the communist regimes in the 1990s, followed by the accession of some countries to the European Union, have initiated the intense development of cities. The development is manifested, among other features, in the renovation of old parks and establishment of new ones. These actions, however, require studies on the role of parks depending on their location in the city, the activities undertaken by park visitors, and the allergenic risks of park vegetation. Taking into account the above assumptions, comprehensive studies of this type were conducted in four urban parks in Rzeszów (Poland) in order to develop recommendations for the city authorities on their spatial management. Harmful impact of parks' vegetation was described by allergenicity index. Park visitors were counted during eight scans in each park. Types of visitors' activities were grouped into five main categories: resting, using playgrounds, cycling, other sports, others. Three categories of the parks land cover were studied: canopy, lawns and paths as well as location of the parks. We concluded that the type of activity undertaken in the park was primarily associated with the land cover structure of the park and its location within the city. A comparison with the use of statistical methods and an evaluation of the parks also showed that diversification of the character and functions of parks in the city is a desirable feature. We have identified three major types of parks using results of studies on the role of parks depending on their location in a city, the activities undertaken by park visitors, and the allergenic potential of their vegetation: downtown parks, open parks, and peripheral parks – requiring different spatial development recommendations to ensure their attractiveness for visitors while simultaneously mitigating their allergy hazard impact.

1. Introduction

Green infrastructure is one of the factors most strongly affecting the quality of human life in cities (Shackleton et al., 2017). It consists of many elements, but well-designed urban parks eagerly visited by city dwellers usually form its core. Due to the very high social acceptance of the establishment of new parks and the prevention of diseases of affluence through physical activity undertaken in parks (Orsega-Smith et al., 2000; Bedimo-Rung et al., 2005; Mowen et al., 2007) or to the benefits manifested in an increased value of properties located in green areas (Jim and Chen, 2010), but also on account of the important environmental functions of such parks (Sadeghian and Vandanyan, 2013), they are one of the most desired forms of urban land management consistent with the idea of sustainable development. It turns out, however, that in spite of the unquestionable benefits that parks bring for the entire urban system and the people themselves (Mowen et al., 2007; Adinolfi et al., 2014), by, for example, reducing the deposition of harmful pollutants (Escobedo and Nowak, 2009; Janhäll, 2015), they can pose real risks to human health due to their excessive production of plant allergens (Cariñanos et al., 2016). They emit also Biogenic Volatile Organic Compounds and pose a threat from the fallen branches, toxic or thorny plants side, as well as fear of wild animals or dogs running without a leash or fear of aggressive behaviour of other people (Cariñanos et al., 2017a). Therefore, the challenge of designing new parks and transforming already-existing parks in such a way as to minimize their negative effects, while at the same time not diminishing

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their attractiveness to the residents, becomes very important. The elaboration of recommendations for city authorities regarding low-allergenic plants in already-existing parks should be based not only on a detailed survey of the vegetation and an evaluation of its allergenicity level, but also on an analysis of the location of the parks within the urban structure, which may affect its ventilation as well as the dispersal of airborne plant pollen along the streets (Peel et al., 2014).

In order to apply these recommendations in the context of a particular city, it also becomes necessary to analyse the purposes of park visits because even the best-designed urban park will not fulfil its role if the residents are not willing to use it. Work on recommendations for urban park greenery shaping, which takes into account both vegetation impacts and the structure of park users' activities, has been successfully undertaken in southern Spain (Adinolfi et al., 2014). A shortage or lack of this type of analysis in Central and Eastern Europe is worth noting, but there have been attempts to estimate the allergenic impact of greenery in a housing estate area in Poland (Kuchcik et al., 2016). Meanwhile, parks in the cities of this region are often young structures, reconstructed after having been destroyed during World War II or established as new elements in the developing cities. When these parks were established, however, their allergenic hazard was not taken into consideration because scientific research in this area was not yet sufficiently developed and generally available in the bloc of socialist countries. Therefore, there is an urgent need to develop recommendations on spatial management in parks in this region, based on studies of the role of parks depending on their location in the city, the activities undertaken by park visitors, and the allergenic potential of their vegetation. Taking into account the above assumptions, a comprehensive study of this type was conducted in Rzeszów, which is located in southeastern Poland (Fig. 1). The main aim of our research was to compare and evaluate selected urban parks in the context of the following features: a) types of activity of park users and frequency of park visits; b) spatial arrangement of parks and the surrounding area; and c) allergenic potential of parks' vegetation. This study served in the pursuit of a practical goal, namely, the development of recommendations for the city authorities regarding land management in the parks located in the city. We believe that this study could provide a methodological model for developing recommendations on spatial management of parks in other cities in this part of Europe.

2. Methods

2.1. Study area

The study was conducted in Rzeszów (50°02′28″N; 21°59′56″E) in southeastern Poland (Fig. 1). It is a medium-sized city with an area of 120.4 sq. km. Its population is slightly more than 188,000. In the city, there are more than 1000 ha of green spaces, including 14 parks covering an area of 81.5 ha. Rzeszów is located in the warm temperate climate zone, and polar maritime air masses are the main climate driver. Over the period 1997–2016, the mean annual temperature was 8.9 °C and the mean annual total precipitation was 693 mm. The mean temperature and total precipitation in the warmest month, July, are 19.6 °C and 111.9 mm, respectively. The mean temperature of the coldest month, January, is -2.0 °C (TuTiempo, 2017). As in other parts of Poland, winds from the westerly sector dominate in Rzeszów, although because of the location of this city, close to the Carpathian Mountains, southerly foehn winds also make a large contribution here. They perform an important role in the process of ventilating the city, blowing away air pollutants along the Wisłok River valley.

We chose to analyse four parks differently located within the city. The criterion for selection was also a diversified land cover structure which allowed us to suppose that the purpose of park visiting will not be the same in each of them. All chosen parks accounted for 32% of all parks area and 2.6% of all green areas within the city.

2.2. Description of parks

The following parks were analysed (Fig. 1): Park Zdrowia (P1), Park Jedności Polonii z Macierzą (P2), Park Kultury i Wypoczynku (P3), and Park Inwalidów Wojennych (P4). They differ both in their size and management as well as in the density of buildings surrounding them (Table 1, Fig. 1). It was only after World War II that plantings were carried out and vegetation maintenance was undertaken, in particular in parks P1 and P4, which were designed as part of a newly developed urbanized area in the 1970s. Park P2 is situated closest to the city's old part and originates from the early post-war period. The largest park, P3, which is located in the floodplain of the Wisłok River, shows some distinctiveness. Some part of its vegetation overlaps here with the remnants of riparian alluvial forests. The vegetation of this park was predominantly planted by the city dwellers by the order of the socialist party, as was common in Soviet countries in those years. This park is part of vast recreationally developed riverine areas. Park P4, the smallest one included in this analysis, is the centre of a densely developed housing estate of high building density, with two public institutions immediately adjacent to it. All the parks have modern playgrounds for children, and as far as their land use structure is concerned, there are open lawn areas as well as shrub and tree areas. Concert shells used for outdoor events are located in two of these parks, P2 and P3.

2.3. Visitors' activities

We assumed that if people willingly come to parks, they are attractive to them. The number of visitors in the parks and the purpose of their visits to the parks' spaces were studied using a momentary time sampling technique known as the SOPARC (System for Observing Parks and Recreation in Communities) method (McKenzie et al., 2006). In this method, the analysis of park users' physical activity was the most important. In our study, all activities undertaken in the park were equally important, which is why we prepared our own visitors counting form, based on research conducted independently in Rzeszów for the riverside recreational areas (Ćwik, 2009) and on the visitors counting method used in Granada parks in Spain (Adinolfi et al., 2014). A reconnaissance conducted in Rzeszów for the riverside parks shows that city dwellers use these parks most intensively during sunny weather in the spring and autumn, outside the summer holiday period. Kasprzyk (2011) indicated that the time of pollination of different allergenic plants in Rzeszów begins in February and ends in the end of September. Therefore, this study was carried out during two seasons of the year (spring and autumn), while also making a distinction between working days and days off, as well as between before noon (10–11 am) and the afternoon (5–6 pm). In total, eight scans were carried out in each of the parks at the turn of September and October 2016, as well as at the turn of May and June 2017. Apart from the number of visitors at any given time, information was also collected concerning the activities undertaken by people visiting each park, with a more detailed division than that proposed by Adinolfi et al. (2014). During a 15-minute scan, the number of people performing the following activities were noted in a specially designed form: walking, walking dogs, sitting on a bench, using a playground, using an outdoor fitness station, using a picnic area and sunbathing, running, riding roller skates or kick scooters, playing ball, cycling, Nordic walking, observing nature, and 'other' – including municipal services. People playing a virtual game that consists in looking for Pokémon characters also had a special place on the form. These activities were grouped into four categories: resting, using playgrounds for children, actively performing sport-related activities, and being involved in other activities. It was also decided that the 'cyclists' group would be distinguished within the 'sport' category, since an assumption was made (later confirmed by the observations) that the presence of cyclists is strongly associated with the park's size, character, location, and infrastructure.

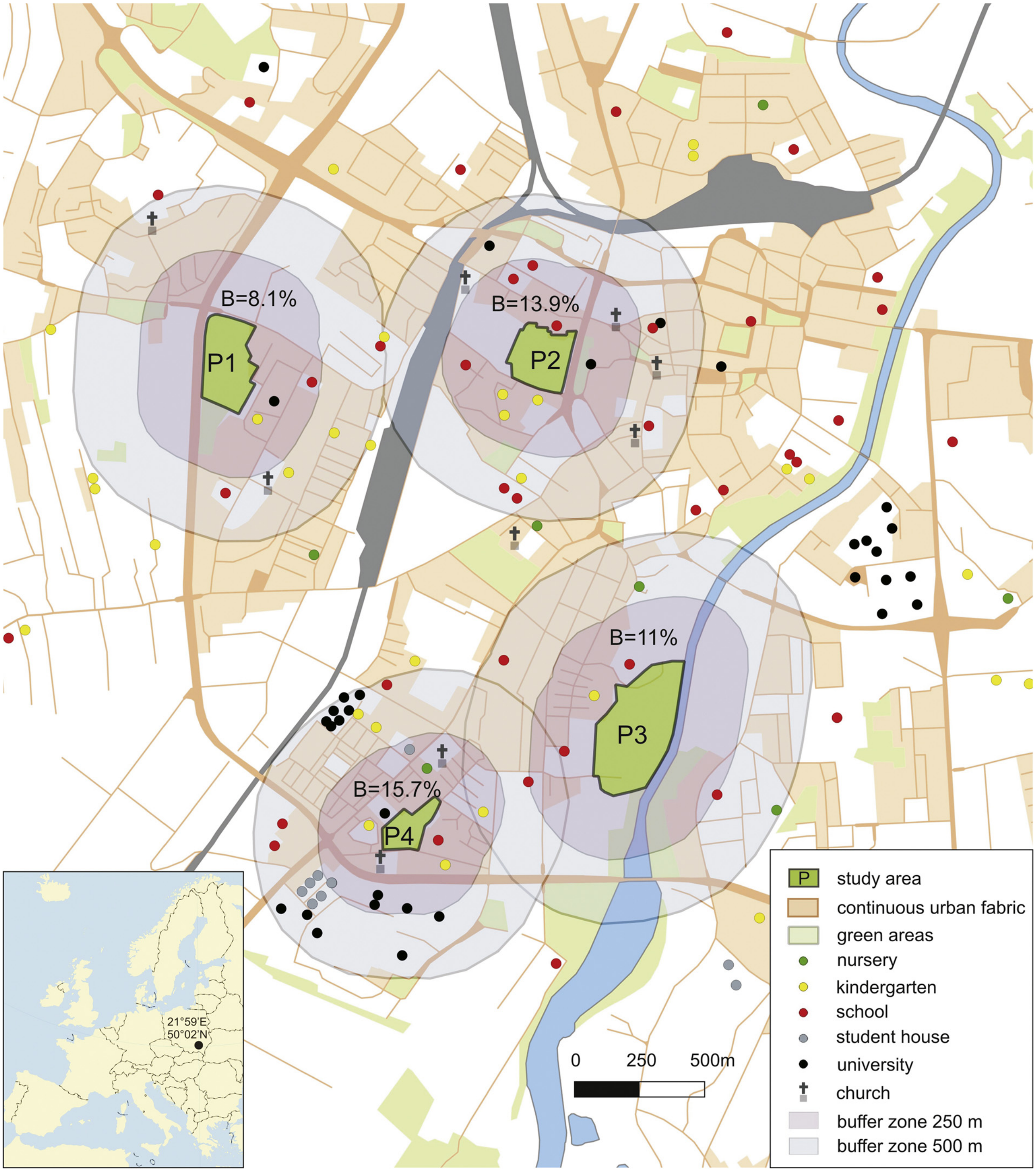

Fig. 1. Public institutions in buffer zones of researched parks. 'B' indicates the percentage of overbuilt area in the entire 250 m buffer zone.

Table 1
Descriptive statistics of dendroflora in parks P1–P4.

Parks	Total area (m^2)	N taxa	n_1	n_2	n/ha	Shannon-Wiener Index H'	Tree species with a contribution on the allergenicity index ≥5% presented in order of decreasing value	I_{UGZA}
P1	62,242	32	695	84	125.2	2.64	*Quercus rubra, Betula pendula, Fraxinus excelsior, Acer platanoides, Tilia cordata*	0.310
P2	49,776	57	439	3559	803.2	3.07	*B. pendula, F. excelsior, A. saccharinum, Corylus avellana, Aesculus hippocastanum, Carpinus betulus*	0.331
P3	121,306	49	836	1282	174.6	2.85	*F. excelsior, A. platanoides, A. pseudoplatanus*	0.127
P4	25,084	44	160	434	263.8	2.89	*B. pendula, Q. rubra, A. pseudoplatanus, A. saccharinum, C. betulus*	0.281

N: number of taxa; n_1: number of tree individuals; n_2: number of shrub individuals (beyond those growing in dense hedges); $n = n_1 + n_2$: I_{UGZA} (Index of Allergenicity of Urban Green Spaces).

2.4. Spatial arrangement of parks and their surrounding area

It was assumed in the study that the degree of potential adverse effects of the parks on people depends not only on the allergenic properties of individual plant species occurring in them, but also on the park's size, land use structure, activities undertaken most willingly in it, and its location within a specific urban structure. The presence of public institutions in the immediate vicinity of the parks, especially those involved in care and education of children and youth, is also of key importance here because people attending these institutions are not only affected on a daily basis by allergenic pollen emitted by the parks, but also use the parks themselves readily and more frequently due to their close proximity. Taking into account the above assumptions, two buffer zones of 250 m and 500 m were designated around the parks using GIS techniques. It is reported in the literature (Adinolfi et al., 2014; Ekkel and de Vries, 2017) that a 300 m zone is the most favourable for this type of analysis, but given the spatial distribution of the city's parks in the centre of Rzeszów, where they are relatively close to one another, even at a distance of less than 500 m, a 250 m buffer zone was considered to be optimal under these conditions. An additional 500 m buffer was designated because such a distance between the place of residence and the entrance to the park is proposed when developing community maps (Pickard et al., 2015). The public institutions located in each of the zones were drawn and illustrated in a figure (Fig. 1). One factor that may affect the park's accessibility for residents is the building density in the park's immediate vicinity. To illustrate the nature of the urban structure surrounding the individual parks, the building layer from a 1:10 000 topographic map was digitized in areas marked with a 250 m buffer. Subsequently, the percentage of the area occupied by buildings in the 250 m buffer was calculated for each park and shown in Fig. 1 as index B. Using earlier made measurements of tree crown width and areas occupied by shrubs, as well as some spatial data available on the Geoportal (n.d.) website, the percentage of the area occupied in the parks by shrubs, trees, open lawns, alleys, and paved spaces was calculated using GIS techniques. The differences between the parks in terms of the area of particular land use types became a point of reference for analysis of the propensity to choose various forms of activity in the respective parks depending on their size and types of land cover.

2.5. Estimating the allergenicity index

The potential allergenicity of the parks considered in this study was calculated by applying the Index of Allergenicity of Urban Green Spaces (I_{UGZA}) developed by Cariñanos et al. (2014). To estimate the allergenicity index, detailed field surveys were carried out, which consisted in making an inventory of all tree and shrub individuals capable of forming flowers in all the parks studied as well as in estimating the crown volume of each individual. In the case of dioecious trees, only male individuals were taken into account to calculate the index. Using a laser altimeter TruPulse 360'B, tree crown height and two perpendicular diameters were measured. In addition, the tree crown shape was described as sphere, cylinder, cone, hemisphere, or cuboid (a row of trees). Crown volume was calculated using standard mathematical formulas, taking into account the flattening of figures. Female individuals, as ones not producing pollen, were not measured. In turn, the diameters of these figures (including female individuals) were used to estimate the area occupied by shrubs and tree crowns. The lawn area was obtained by deducting the area covered by shrubs, paths, and paved areas from the park's total area. Assuming sward height to be 0.25 m, its volume was calculated.

The biological parameters necessary for the calculation of the index were consulted in the database created for this purpose (Cariñanos et al., 2014, 2016). In this database, each parameter with an implication in the Value of Potential Allergenic (VPA) is assigned a numerical value between 0 and 3 according to its contribution to the intrinsic allergenicity of the species. As a reference, maximum values are assigned to species with wind-pollinated strategy (3), with flowering periods longer than 6 weeks (3), and with high allergen potential referenced (3). An allergenic potential value of 4 can be assigned to all pollen types considered as major local allergens, so the highest VPA is 36 (Cariñanos et al., 2014; Cariñanos et al., 2016). The resulting value, between 0 and 1, will express the possible allergenic risk for visitors who have a pollen allergy at certain times of the year. A value of 0.3 can be considered a threshold at which allergy sufferers start to experience discomfort (Cariñanos et al., 2017b).

2.6. Data analysis

The parks were compared in terms of activity undertaken by the park users. For this purpose, the data correlation matrix was generated and then Multidimensional Scaling (MDS) was performed. Scatter plots with points corresponding to the parks are the outcome of this analysis. The further the points are from each other, the more the parks differ from each other. The analysis was performed with a division into morning and afternoon, taking into consideration whether it was a working day or weekend as well as without any divisions. The parks were also compared in detail for each category of visitor activity by the nonparametric statistical Kruskal-Wallis test, having first checked for normal distribution using the Shapiro-Wilk test and for the homogeneity of variance by the Brown-Forsythe test. The statistical hypotheses were tested at $\alpha \leq 0.05$. Statistical analysis was performed using Statistica 12 software. The Shannon-Wiener biodiversity index H' (Morris et al., 2014) was calculated using PAST 3.0 software.

3. Results

3.1. Visitors' activities and arrangement of parks

The largest number of visitors was recorded in park P3 (Fig. 2). Here, the average from all scans was 273 people. This was also the park with the highest absolute number of people observed during one scan: 729. The lowest number of people visited park P1 – on average 64 at a particular time period. However, taking into account the park area and number of visitors, the downtown parks – P2 and P4 – have the highest visitor density and park P1 – the lowest (Fig. 2). Visitor density in the parks clearly depends on the day and time. In all the parks except P4, the largest number of people was observed on weekend afternoons, whereas in P4 they were observed in the afternoon on working days (Fig. 2). Park P4 is located in the middle of a large housing estate and is used by the local residents (Figs. 1 and 3) rather than by people from other parts of Rzeszów, who would come to this park for a special purpose, as in the case of the riverside park P3. The fewest number of people go to all the parks on weekend mornings.

Interestingly, there are differences between the parks in terms of the purpose of visit and spatial arrangement (Fig. 4A and B). Regardless of the time of the day, P2 and P4 are most similar to each other, whereas distinct differences can be seen between P1 and P3 (Fig. 5). In each park, resting people are predominant, but there are high numbers of people using the two well-equipped playgrounds in P1 (Fig. 4B). During the field observations, many parents walking with their children were also observed, mainly in the afternoon on working days. A distinct duality of land development can be seen in this park. Much of it is densely covered by trees and consequently visitors avoid such areas. Lawns are also a significant part of the park, but the percentage of cycling and walking paths is low. This affects the low number of cyclists (Fig. 4A and B).

What distinguishes the downtown P2 park is its balanced land cover structure (Fig. 4A). It certainly affects the park's attractiveness to people resting in it. In spite of its small area (Table 1), it has two fountains, two playgrounds, an outdoor fitness station, a concert shell, and the most diverse vegetation (index H'; Table 1). The attractiveness

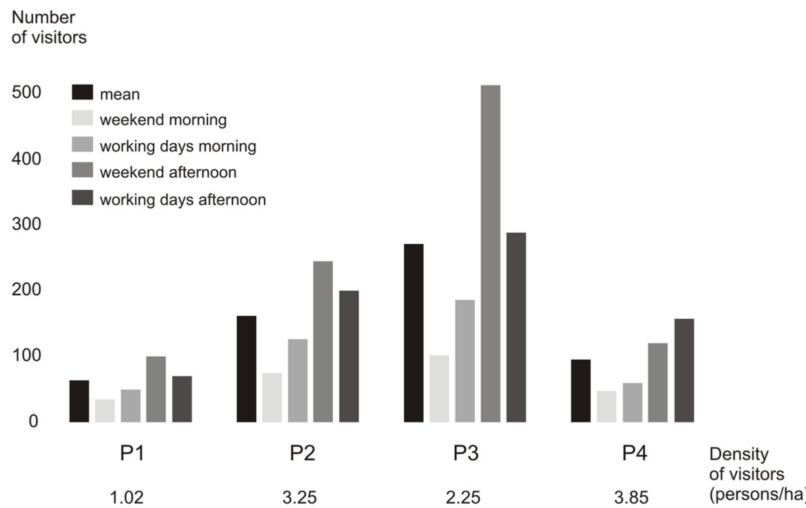

Fig. 2. Frequency of visitors using parks.

of park P2 is reflected in the large variety of reasons for visiting, with the 'others' category clearly standing out in this respect (Fig. 4B, Kruskal-Wallis test: H = 11.489; 0.0094). This category primarily consists of people walking through the park to the neighbouring institutions without any intention of staying in the park, especially before noon. Groups of students from the nearby schools who visited the park during breaks or who participated in physical education lessons were observed here several times. Many people walking through the park were also recorded on Sunday afternoons. These were people walking to the nearby churches (Fig. 1). The greatest number of people playing the Pokémon Go game, which was a very fashionable online game in 2016, were also observed in P2 (Fig. 3). On working days and regardless of the time of day, the structure of people visiting this park is similar to that for P4, as shown by the MDS analysis (Fig. 5). Furthermore, this analysis reveals that in terms of the type of activity undertaken by the park users, P3 clearly stands out from the others at all times of the day (Fig. 5). In the first place, it is characterized by the highest percentage of cyclists (Kruskal-Wallis test: H = 16.579; p = 0.0009; Fig. 4B). Park P3 stands out statistically from the others by virtue of the fact that there are specially arranged bike lanes (Fig. 3), which are part of a large system of riverside bike paths, and cyclists just cycle through this park. In terms of land management in park P3, paved areas occupy a very large percentage (Fig. 4A). There are also many open spaces that are used by sunbathing and picnicking people, which was occasionally

Fig. 3. Visitors' activities and the arrangement of parks P1–P4 (phot. by A. Ćwik, 2016 and 2017).

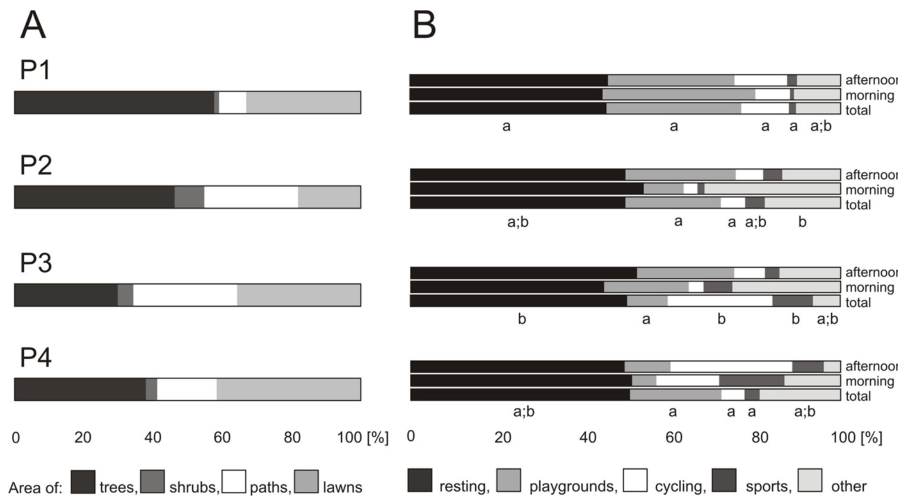

Fig. 4. The parks' land cover structure (A) and park visitors' activities (B). Parks similar in visitor numbers are marked with the same Arabic letter (Kruskal-Wallis test and post-hoc test); the analysis was carried out for each activity separately.

noted in the other parks. P3 is further distinguished from the other parks by the fact that it has the lowest percentage of canopy in the entire land cover structure (Fig. 4A), and consequently the park has a landscaped character. In park P3, the greatest number of people practise sports, which distinguishes it from the other parks (Kruskal-Wallis test: H = 18.072; p = 0.0004). It should be stressed that unlike P1 and P2, there were more sportspeople here before noon. This park does not differ from the others in the average number of people in the playgrounds (Kruskal-Wallis test: H = 4.257; p = 0.235), although the largest number of groups of preschool children walking and using special

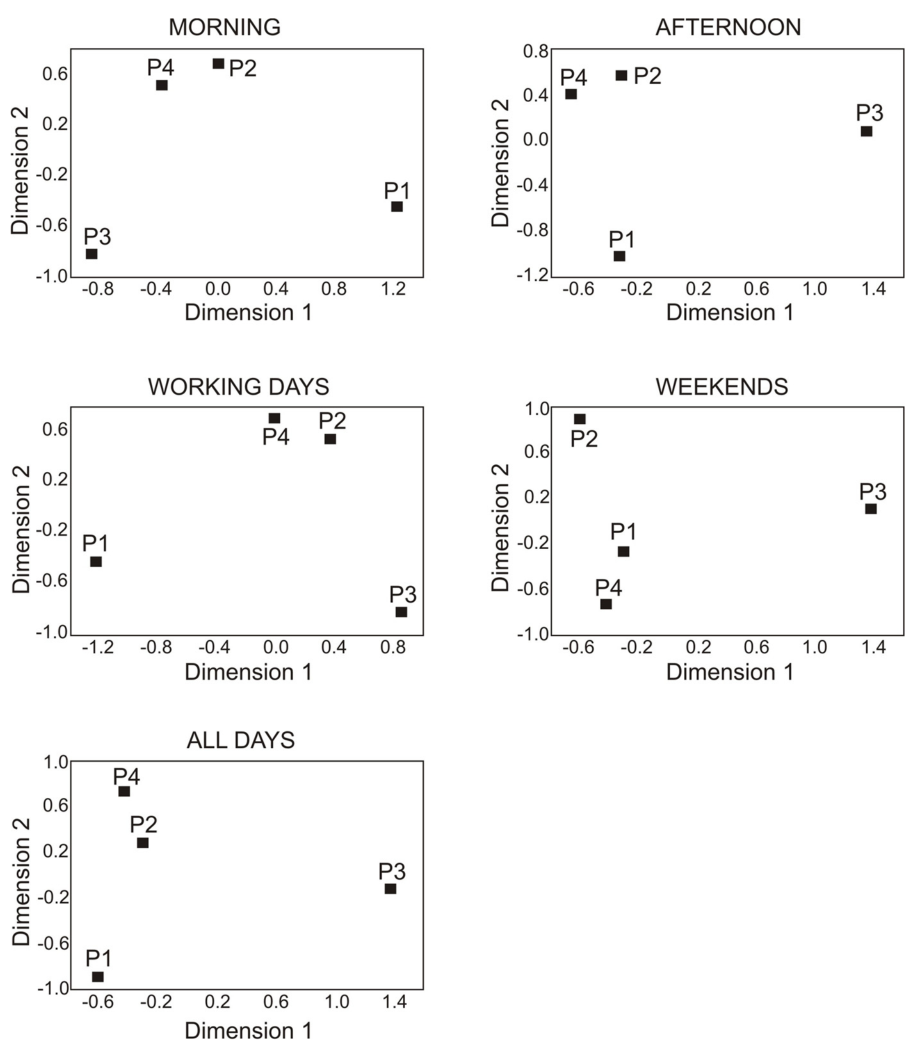

Fig. 5. Scatter plot visualizing the level of similarity among parks in terms of the structure of visitors' activities (Multidimensional Scaling (MDS)).

attractions for children, such as the choo-choo train or go-kart rides, was observed in this park. City events are also organized in the local bandshell, which occasionally significantly increases the number of park visitors. It is worth noting that there are river-related activities in P3, such as angling (Fig. 3). More people observing or photographing nature were seen there, as well as children feeding ducks.

Park P4 is the smallest studied and the most tightly surrounded by buildings (Table 1, Fig.1). Lawns predominate in its land cover structure but proportion of open and tree-cover spaces is similar (Fig. 4A). Nevertheless, the open spaces are rarely used and the visitors mainly occupy the benches along the paths and the playground. A school, a church, and one of the university faculties are directly adjacent to the park (Fig. 1). Consequently, many people walk through this park in order to reach these institutions, hence the high percentage of the 'others' category noted. (Fig. 4B). The high percentage of cyclists in afternoons (Fig. 4B) is attributable to the fact that these are children learning to ride a bike or riding their bikes in a relatively safe environment. Many elderly people from the nearby apartment blocks rest here (Fig. 3).

3.2. Spatial arrangement of surrounding area

The location of the parks in the context of the transportation routes in Rzeszów and the density of the buildings in the immediate vicinity of the parks (index B) divide them into two groups. Parks P2 and P4 are typical urban parks located in densely built-up areas, as indicated by the much higher values of index B (13.9% and 15.7%) than for parks P1 and P3 (Fig. 1), which are located outside the city centre.

Park P1 is surrounded by an area with the lowest building density (B = 8.1%) and its ventilation is facilitated by the park's favourable location to the west of the city centre, which is of major importance because westerly and south westerly winds prevail in Rzeszów. The city's western bypass, adjacent to the tree-covered part of the park, is a barrier to the park's accessibility (Fig. 1). However, many people were observed passing through the park to the large shopping centre located on the other side of the road.

Park P2 is characterized by the highest visitor density (almost 4 persons/ha, Fig. 2), although there are significant spatial barriers in its vicinity that limit its accessibility. People willing to get to the park need to cross a railway line and a busy city road (Fig. 1).

Despite park P3 having the greatest number of visitors (Fig. 2), it has a low index B value (11%) and a medium visitor density (2.25 persons/ha). Given its location along the river valley (Fig. 1), it is a barrier to accessing the park.

The situation of park P4 is quite different. It does not come in direct contact with any spatial barrier, but the city's southern bypass is rather close, within the 250 m buffer zone. It may discourage many young people who study or live within the 250 and 500 m buffer zones (Fig. 1) from coming to the park. During the field investigations, only a few students were observed studying in the park.

The analysis conducted both in the 250 m and 500 m buffers shows that the areas surrounding parks P2 and P4 are characterized by the greatest accumulation of educational institutions. Nine and twelve institutions, respectively, are located in their closest zone, while in the wider 500 m zone there are 20 and 36 (Fig. 1), but with 36 institutions, park P4 clearly stands out of all the parks analysed. In the case of P2, these are predominantly nursery schools and schools, whereas the structure of the institutions in park P4's buffer zones varies greatly (Fig. 1). It is worth mentioning that in the immediate vicinity of park P2 there are three very large regional public administration offices and shopping centres, as well as two churches. In the immediate vicinity of park P1, only 3 educational institutions are located, whereas in the wider buffer there are only 10. The situation is similar in the case of P3 where there are 5 and 9 institutions, respectively, mostly schools (Fig. 1).

3.3. Allergenic hazard of parks

The vegetation of the parks studied varies greatly. In total, 90 tree and shrub species representing 24 families, primarily angiosperms, were identified in all the parks. Tree species typical for urban parks, mainly native ones, were found in the parks, and their frequency, age, and crown volume influenced the I_{UGZA} index value (Table 1). Park P2 is characterized by the greatest biodiversity (H') and the highest taxonomic richness (N = 57). Silver birch and common hazel, species with the highest VPA (36), are found here in great numbers. This fact and the large density of woody plants contribute to the highest allergenicity index (I_{UGZA} = 0.331). A very unfavourable feature is to be found in this park: the playground was surrounded by two silver birch trees, one of the most allergenic species (Fig. 3). The lowest number of species is found in P1 and here the biodiversity is the lowest. In spite of the low density of individuals, this park is characterized by the second value of the I_{UGZA} index (Table 1). The park with the largest area (P3), the highest number of visitors, and the lowest number of adjacent public institutions is characterized by the lowest allergenicity index (Table 1).

4. Discussion

From the point of view of urban life quality, use of public green spaces such as urban parks seems to be a much-desired phenomenon. However, people visit parks for different purposes and remain there for various durations of time. Sometimes, park visits are driven by necessity, such as the fact that the route to work or school goes through the park like in P2, whereas in other cases park visits are an optional activity associated with, for example, the desire for leisure. The third type of activity is a social one, such as when a group of people pursue some activity together (Gehl, 2010). In the Rzeszów parks, all of these kinds of activity were noted in different proportions. As reported by Lin et al. (2014), nature-oriented visitors are the most frequent park users in Brisbane, Australia. Interactions of park users with nature were also important for the parks' visitors in Berlin, Germany (Palliwoda et al., 2017) but were not frequent in Rzeszów. In addition, relatively few team games were observed here, even though each of the Rzeszów parks has the open areas that are necessary for this type of activity (Goličnik and Ward Thompson, 2010; Ignatieva et al., 2017). This may be due to cultural context, arising from the fact that in Polish cities 'Keep off the grass' signs are often erected. This may create a natural resistance to using the lawns.

One indicator of a sustainable city is not only the fact that people visit public spaces, but also that this visit should be as long as possible (Gehl, 2010). According to Mowen et al. (2007), park use duration is related to park proximity. However, a study by Lin et al. (2014) reveals that park visit duration and the determination to get to the park in spite of having to travel a significant distance depend more on park users' attitude towards nature than on the park's arrangement. The frequency and willingness to visit the park also depends on the day of the week (Bertram et al., 2017). The city dwellers have a little time for leisure during weekdays and then they prefer parks in closer proximity but the distance from houses are not so important to them during weekends. Significant factors influencing park use include not only the proximity of the park, but its size and quality as well (Rigolon, 2016). Tree density also proves to be a crucial factor - in cities, there should be parks with a diverse structure with a balanced proportion of open and tree-covered areas so that everyone can use them according to their preferences (Bjerke et al., 2006). Our observations fully confirm this conclusion. A long visit in a badly designed urban park may be risky for sensitized people because of allergenic plant pollen (Lovasi et al., 2013), and in this sense it may lower the quality of their lives. The most 'dangerous' parks in Rzeszów are P2 and P4, which are tightly surrounded by buildings with educational institutions housed in them. On the one hand, a high density of buildings may result in more people coming to the park from the neighbourhood, like in park P1 (Rigolon, 2016), but on the other hand, it impedes the park's ventilation (Wong et al., 2011). This may ultimately increase the allergenic hazard (I_{UGZA}), due to the properties of the plants growing there (VPA) and their proportion in the park's area. It appears that the proximity of busy streets and railroads modifies the risk arising from the presence of the plants. A busy road can be a channel for blowing traffic-related pollutants into the park and may strengthen the negative effects of plant allergens. Such a situation may occur in the park P1 although on the other hand a wall of densely planted trees protects the park against the phenomena. Particular attention should be paid to this park because relatively many children visit it. In this park, like those described above, the I_{UGZA} index is higher than the threshold value, which is 0.3, according to Cariñanos et al. (2017b). Elderly people, who are less resistant to the adverse impacts of environmental factors, form another risk group (Todo Bom and Mota Pinto, 2009). This social group most readily used parks P2 and P4. The good structure of the parks, with a similar proportion of open and tree-covered spaces, as well as its increased visual attractiveness and comfort facilities, due to the successful renovations of the parks carried out a few years ago, encourage resting here. It is worth noting that downtown parks are adjacent to many educational institutions, public administration offices, and other places gathering large numbers of people, such as shopping centres. Almost 40 people walking through the park were observed several times in P2. This increased number of park users is probably due to the vicinity of these institutions. Every day, people ranging from several dozen in number (in the case of day-care centres and nursery schools) to several hundred (schools, university faculties, and student dormitories), and even several thousand, as in the case of the shopping centres, visit these places. For the purpose of this analysis, only the location of the school and educational institutions was examined because children and young people are considered to be special risk groups as far as the impact of plant allergens on humans is concerned (Winer et al., 2012; Izquierdo-Dominguez et al., 2017). However, these groups readily use the parks. They are represented in the parks in equally large numbers, regardless of the park area. Therefore, the downtown parks could become a pilot area for the implementation of allergen risk monitoring and the dissemination of information concerning such a risk among the general public. The so-called sociotope maps, developed for many Swedish cities and showing the social values of greenery based on the investigation of the frequency of visits and questionnaire surveys, could become a particular inspiration (Ståhle, 2006; Xiu et al., 2017). Similarly, in the USA, questionnaire surveys are conducted among people visiting urban parks. They are to improve the management of those parks (Jennings et al., 2016). By expanding this type of research to include all the parks in Rzeszów, a map could be made for the city that would indicate popularly places to visit that are attractive to many social groups and also safe for allergy sufferers. Furthermore, benefits from physical activity taken in urban environment are linked to perception of such places as safe (Weimann et al., 2017). The possibility of practising sports, which prevents obesity and other diseases of affluence, is considered to be one of the greatest benefits that urban parks bring to a society (Orsega-Smith et al., 2000; Bedimo-Rung et al., 2005; Schipperijn et al., 2013). The study described in this paper demonstrates that for a park to be attractive for the practising of sports, it must have the appropriate infrastructure, as in riverside park P3. Its open landscape and large paved areas encourage sports activities. All the parks have the necessary infrastructure (an outdoor fitness area), but in this park there are particularly good conditions for running, roller skating, and Nordic walking due to the long streets and a path that connects it to the recreational areas in the southern part of the city. This is consistent with the findings of Schipperijn et al. (2013), who directly link the possibility of physical activity in urban green areas to the existence of bicycle and pedestrian paths, attractive views, and other amenities, such as water features and parking lots. The size of the park is also essential; an area of 5 ha is accepted as the minimum for promoting outdoor physical activity (Schipperijn et al., 2013). With more than twice this area, park P3, among the parks studied, attracts the greatest number of park users who practise physical activity there. The proximity of the river may be a barrier to access the park but it is an additional attraction for city residents and they also go there to seek a contact with nature that it provides. At the same time, the threat from pollen allergens in this park is lower. This location of the park at the river is of major importance for its ventilation because local winds blow mainly from a southwesterly direction, which coincides with the course of the valley. Relative to the other parks, P3 is worth recommending on the map of Rzeszów, even for people suffering from a pollen allergy.

5. Conclusions

The development of recommendations for establishing new urban parks and for renovating already-existing parks requires an interdisciplinary and comprehensive approach to problems associated with visitors' activity, the spatial arrangement of parks, and their location, as well as assessment of the allergenic effects of vegetation on park visitors and persons staying within the park's impact zone.

The study has shown that the type of activity undertaken in the park is primarily associated with the land cover structure of the park and its location within the city. The comparison and evaluation of the parks also show that diversification of the character and functions of parks in the city are a desirable feature.

The small downtown parks in particular require interdisciplinary analysis in developing recommendations because the greatest number of factors influences their functioning. On the one hand, they are surrounded by densely built-up areas, while on the other hand they have the most diversified spatial arrangement and the most diverse vegetation. They are also the most loaded with visitors. Therefore, one needs to maintain balanced proportions between open and shrub- and tree-covered areas, as well as a rich infrastructure that provides diverse leisure opportunities. Measures designed to reduce the allergen risk in this type of park should involve the gradual replacement of species with the highest VPA under specific climatic conditions with other species that do not cause allergies and which give shade, particularly near playgrounds. In the investigated parks, species whose planting should be reduced, mainly include the following trees: birches, common hazel, oak, common ash, and European hornbeam. At the same time, care should be taken to ensure that trees do not form clusters that are too large, because this discourages people from undertaking physical activity in such areas.

Apart from the downtown parks with the highest visitor density, there are open parks with a landscape character that perform completely different roles. The riverside areas, which are the only convenient place to practise sports intensively, are such an example in Rzeszów. At the same time, the threat from allergenic pollen is lower in this type of park. The land cover structure, with a large proportion of lawns and paved areas, should be maintained here, and the lawns should be regularly mowed before flowering.

The peripheral parks, located on the city outskirts but close to residential areas, also perform an important role. Although they are not crowded with visitors, they provide recreational and walking areas for families with young children. Therefore, in parks of this type, special efforts should be taken to plant low-allergenic species and, as for the other parks with large lawn areas, the grass should be regularly mowed.

The need also arises to provide the general public with information on potential aeroallergen risks because many educational institutions are located in the direct vicinity of the parks. We suggest that the city authorities collect such data and provide them to child care institutions so that outdoor activities are safe for children and other sensitized people.

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