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# Changes in the area of urban green space in cities of western Poland

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**Abstract**. Extensive and continuous areas of urban greenery are essential for the proper functioning of cities and for achieving optimal natural conditions. The aim of our study was to investigate the changes in the areas of public green space of Szczecin, Poznań and Wrocław in the years 1996–2013, and compare data on public greenery with demographic data and changes in the spatial development of the described cities. We used a linear regression and exponential regression to explain the results. In our opinion, it is necessary to establish the appropriate proportion of public greenery to the built-up areas in cities. Otherwise, we will be observing an adverse reduction of green areas in relation to residential areas. Surveys also indicate the need for action to prevent the outflow of population to the suburban areas.



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## 1. Introduction

According to the data presented by the United Nations, over 54% of the population lives in urban areas, and this proportion is expected to increase to 66% by 2050. It should be remembered that it took only 64 years (from 1950 to 2014) to dramatically increase the population of people living in cities: from 746 million to almost 4 billion (United Nations, Department of Economic and Social Affairs & Population Division, 2014). Changes in land use of urban areas and the changing the type of soil cover in the cities from biologically active zones and public green areas to impermeable territories are harmful both to the environment and residents (Pauleit et al., 2005; Grimm et al., 2008). Urban green spaces in cities include parks, gardens and street vegetation. All these types of greenery provide many benefits to the urban environment, helping to preserve and enhance biodiversity in urban ecosystems (Tzoulas et al., 2007; Kabisch, Haase, 2013). Additionally, public green areas fulfil many important functions: provide fresh air, reduce noise, lower the temperature, give the possibility to have contact with nature and biological diversity, and have positive effect on mental and physical health (Chiesura, 2004; Maller et al., 2006; Bowler et al., 2010). Public green also plays an important sociological role as a meeting place for neighbours and for integration within a community (Kim, Kaplan, 2004; Martin et al., 2004; Kabisch, Haase, 2014).

This perception of public green space and its functions clearly indicates that it is part of green infrastructure. It is in agreement with the rule that green infrastructure consists both of natural and anthropogenic ecosystems which integrate built-up areas to provide as wide access to environmental, social and infrastructural services as possible (Young et al., 2014). The literature lists a wide range of attempts to introduce a typology and categorisation of elements of green infrastructure and ecosystem services. Ahern (1995) presented a general typology of green infrastructure systems, which is oriented to the scale, goals and strategies of development as well as the scenic context. However, this approach to the issue does not provide much information whether planned green areas or green areas which are being made will have favourable influence on the services of ecosystems for local communities. Dunnett et al. (2002) divide green space into four main categories: arranged public green space, green space with specific functions, semi-natural green space and green belts. The authors of this study did not concentrate on the functions of green space but on its usefulness for inhabitants. The typology of ecosystems and green infrastructure published by the United Nations Organization (Millennium Ecosystem Assessment, 2005) combines the ecological and social approach, allowing for dependences resulting from property rights. This typology distinguishes four main categories of green infrastructure and ecosystem services: maintaining (primary agricultural production), providing (source of water, fuel, wood), regulating (influencing the climate) and cultural (aesthetics). Additionally, the UN typology allows for five social components which result from the presence of green infrastructure and have influence on social and ecological changes: safety, availability of basic materials ensuring quality of life, appropriate social relations, health and freedom of choice and activity. Tzoulas et al. (2007) used the existing typologies of green infrastructure and ecosystem services to make a concept combining thinking about public green space, ecosystems and their influence on inhabitants' health. A report prepared by the European Environment Agency (European Environment Agency, 2011) also distinguishes four main categories of green infrastructure and ecosystem services: regulatory, habitat-related, productive and informative. It also stresses the benefits resulting from the division of elements of green infrastructure depending on the type of ecosystem services. Although the report does indicate direct benefits for the ecosystem resulting from a particular type of green infrastructure, it notices potential conflicts between decisions of the European Union and benefits resulting from the production of ecosystems at the expense of green infrastructure (increasing the production of biofuel crops at the expense of forested areas). Other authors propose an improvement of previous typologies by developing ecosystem output indicators for elements of green infrastructure related to forestry in urbanised areas (Dobbs et al., 2011). Simultaneously, Dobbs et al. (2011) stress the relation of ecological functions and social processes occurring in green infrastructure facilities. Their study also indicates the

fact that the socio-political and biophysical context is often skipped in research on green infrastructure and ecosystem services. Mell (2013) notes the role of green infrastructure and ecological tools in designing and urban planning, emphasising the decisive influence of humans and the relation between humans and green space on the success of each investment related to the creation of green infrastructure facilities.

As can be observed, numerous studies refer to types and functions of public green spaces in urban areas, but few works inform about changes of the surface and types of land use of public green spaces. This is all the more important because it is expected that in the near future the amount of urban open spaces in European cities (currently it is 20–40% of cities) can be significantly reduced (Fuller, Gaston, 2009; Tosics, Nilsson, 2011). A similar trend was observed by Asian researchers who emphasized a decrease in the acreage of green areas at the expense of built-up lands (Liu et al., 2014). Fuller and Gaston (2009) also claim that the number and area of public green spaces is more associated with the area of the city than with the number of its residents. Small cities with compact development demonstrate a smaller amount of green areas per capita (McConnachie, Shackleton, 2010; Tan et al., 2013). The analysis of existing legislation in terms of "green spaces" concept shows a lack of clear criteria for the delimitation of these areas. Guidelines for their formation indicate that this concept is one of the least precise terms used in Polish spatial planning (the Construction Law Act, 1994; Bonenberg, 2011; the Spatial Planning and Development Act, 2012; the Nature Conservation Act, 2013; Sepioł, 2014). The basic tools used in spatial planning in Poland are: at the national level – the National Spatial Development Concept, at the level of the voivodeship – Regional Spatial Development Plans, at the local level – Land Use Plan and Local Zoning Plans and Planning Permissions. At the same time, it should be noted that depending on the form or function of green areas, their administrators are different local self-government units. Most often, each of these institutions perceives the green issues fragmentally, and it contributes to the lack of holistic green management.

The main question of our study was to analyse changes in the area of various types of public green spaces in the largest cities of Western Poland: Szczecin, Poznań and Wrocław, in the years 1996–2013 and to analyse the trend lines of those changes. In addition, our intention was to compare the data on public green with demographics and changes in spatial development of the studied cities. The results can be useful for local authorities and local communities—both in Poland and other former communist bloc countries—as they can indicate the direction of further actions and spatial development plans, resulting in improving the citizens' quality of life and increasing the amount of available urban green space and green infrastructure.

## 2. Research materials and methods

The main sources of data for our study were: information on traditional greenspaces, CORINE Land Cover (CLC) obtained from the Inspection for Environmental Protection (Inspection for Environmental Protection, 2015) and statistical data from the Local Data Bank which is the largest collection of information on the socio-economic, demographic, social and environmental status of Poland for statistics purposes (Central Statistical Office of Poland, 2015).

Available statistics on migration of the population made it necessary to create a short questionnaire that would help identify reasons for choosing one's place of residence. An additional data source was a representative survey the purpose of which was to describe trends in the movement of the urban population, its directions and reasons for migration. We conducted anonymous intercept surveys among randomly selected adult residents of the studied cities and their surrounding areas. The purpose and content of the survey were explained to each of the respondents. It was also emphasized that participation in the survey was voluntary. The poll was carried out in urban open areas. Respondents were enquired about the factors which they believed determined the choice of a place of residence. The following answers were available: location and proximity to the downtown area, better communication solutions, greater availability of public green spaces, the price of real estate, the availability of jobs, a sense of security, prestige and other. The participants were also asked whether they had moved in

the prior 15 years. The possible answers were yes or no. If the answer was yes, the respondents were requested to indicate whether they had moved: within the city, outside the city but within the district, or chose another region of the country. In every case, the participants were asked to designate the reasons for moving by choosing one of the available answers or providing answers of their own. Other questions regarded age, sex, education, marital status and the number of children.

The subject of our research comprised the three biggest cities of Western Poland: Szczecin, Poznań and Wrocław (Fig. 1, Table 1). Those cities are the capitals of voivodships, showing a geographic-historical similarity, and can be characterized by similar socio-economic conditions.

Szczecin (53°25'27.1" N, 14°33'34.8" E) is the third largest Polish city in terms of area (300 km2) and seventh in terms of population (over 400,000). The green part of the city is a wedge-shaped system of vegetation with fragmented public green areas in the city centre. Green wedges are formed by three forest complexes, and there are also more than 60 other public green spaces of various types, e.g., parks, squares, protected areas and valuable natural areas. The biggest concentration of public green space is in the Central Cemetery (over 168 ha) which also functions as a park (Urbański et al., 2009).

Poznań (52°24'30.4" N, 16°56'03.4" E) is the seventh largest Polish city in terms of area (over 261 km2) and fifth in terms of population (over 540,000). The green areas in Poznań form a system of green wedges and rings, which means that greenery is arranged as four wedges in naturally-shaped river valleys of the Warta, Bogdanka and Cybina. Apart from forest areas and residential green, there are over 270 separate green facilities, including: numerous parks, lawns, gardens, allotments, scientific and research parks, two zoos and 24 cemeteries (Parysek, Mierzejewska, 2006; Urbański et al., 2009).

Wrocław (51°06'34.8" N, 17°01'56.5" E) is the fifth largest Polish city in terms of area (over 292 km2) and fourth in terms of population (over 630,000). Wrocław public green areas are a part of a dispersed wedge and ring system. The rings are formed by: a) Promenady Staromiejskie around the Old Town, extended to adjacent parks: pl. Wolnosci, Staromiejski, Wzgorze Partyzantow, Slowackiego

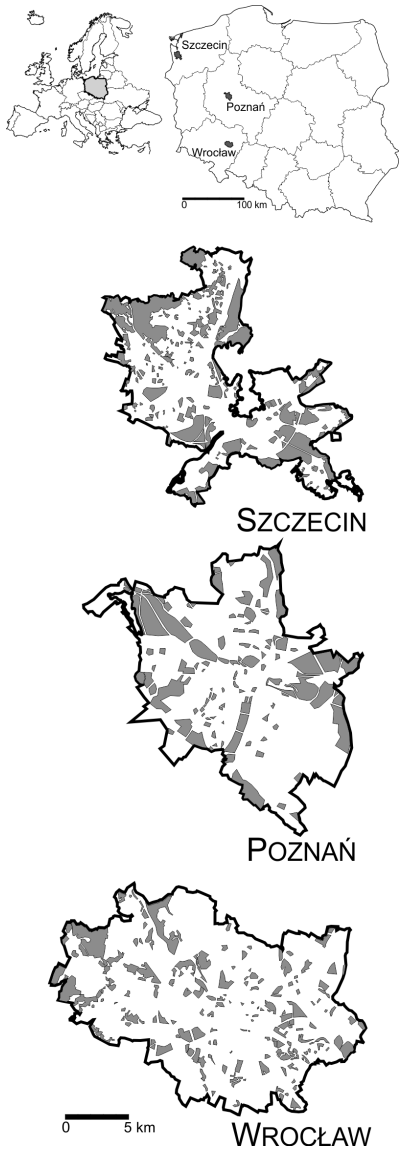


**Fig. 1.** Location and structure of green spaces in the studied cities
*Source:* Authors own work

and Wzgorze Polskie; b) parks located in some distance from the central parts of the city and by c) large municipal forest complexes in Psie Pole and state forests surrounding Wrocław from the north and west (Urbański et al., 2009).

In order to better explain the results, we used linear regression and exponential regression. The statistical method used allowed us to estimate the value of the response variable (dependent) for given values of the explanatory variable. The analysis included linear regression where the distribution of the variables was linear and directly or inversely proportional, and the graph of a function could be described by the formula of the linear function

**Table 1.** Parameters of the studied cities

| City | Area of the city [ha] | Public green area [ha] | Population | The share of green space in the total area of the city [%] | Public green area per resident [m²] |
|---|---|---|---|---|---|
| Poznań | 26191 | 3474.27 | 548028 | 13.26 | 63.40 |
| Szczecin | 30055 | 3119.81 | 408172 | 10.38 | 76.43 |
| Wrocław | 29282 | 2795.05 | 632067 | 9.54 | 44.22 |

*Source:* Authors calculations based on Central Statistical Office

y = ax + b. To calculate coefficients a and b, we used the method of least squares to make the best fit of the regression line to the data collected. Part of the analysed data demonstrated exponential distribution, hence the use of exponential regression where the graph of the function took the form $y=ae^{bx}$.

## 3. Research results

### 3.1. Statistical analysis

On the basis of data obtained from the Local Data Bank, we performed analyses used to determine a trend in the change of the area occupied by different types of greenery in the analysed cities. The study included data from the years 1996–2013 (except for 2004 and 2005 for which data were unavailable). We observed the greatest variability in the area occupied by parks (Fig. 2). In the case of Wrocław, an upward trend from 2.06% to 2.80% of the total area of the city was recorded. Unfavourable situation was observed in Poznań where the area of parks declined from 1.72% to 1.33% despite the fact that in 2006 there was an increase to 1.93%. The lowest proportion of parks in the general area of the city was recorded in Szczecin where in the years 1996–2013 it was in its narrowest range and averaged 0.54%.

The area of squares ranged from 0.16% in the total area of Szczecin in 2013 to 0.75% in Wrocław in 2006 and 2007. We observed the least favourable situation in Wrocław where we noted the biggest decline in the territories occupied by green areas in

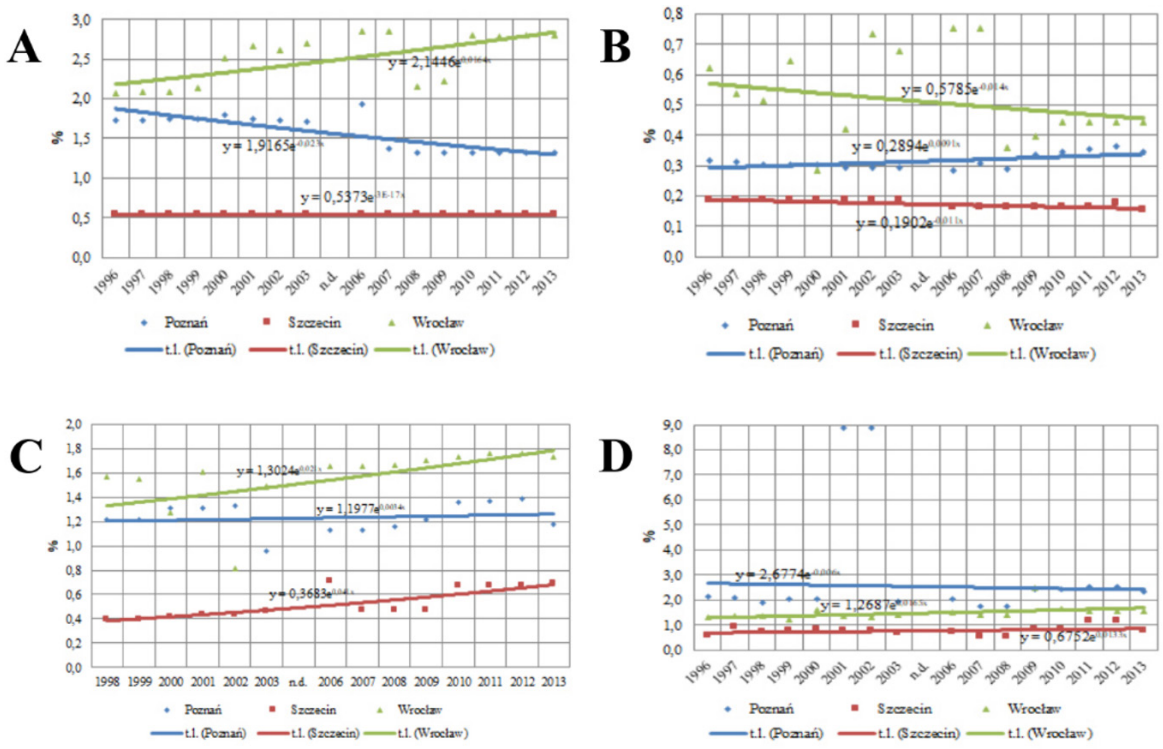


**Fig. 2.** Changes in the proportion of green space in the total area of the studied cities
Explanation: A – parks; B – squares; C – greenery along streets; D – greenery in residential areas; t.l. – trend line
*Source:* Authors elaboration based on Central Statistical Office

the city—by as much as 0.4%. In the case of Poznań, analyses indicated a systematic increase in the area of squares in the general area of the city, which potentially could be caused by land development that had not been arranged before. Over the 15 years, we observed a steady increase in the share of street vegetation in the studied cities. It was the highest in Wrocław and Szczecin. The lowest proportion of street greenery to the total area of the city was recorded for Szczecin—less than 0.7%. The lowest amplitude of area changes over time was noted for residential vegetation. Available statistics show a very high increase in the area of residential vegetation (to 8.9%) in Poznań in 2001 and 2002. It is, however, impossible to explain as these data were not reflected in subsequent years.

The figure below (Fig. 3) presents the changes in plantings and losses of trees and shrubs in Poznań, Wrocław and Szczecin over the 15 years in question. In Wrocław, we observed a downward trend in the number of trees planted in the city and, at the same time, the trend in the number of re-moved trees was constant. The most unfavourable situation has been noted in Poznań where the number of removed trees significantly exceeded the number of trees planted, especially in 2009, 2010 and 2011. Moreover, a very clear upward trend for the number of trees removed from the city can be observed for the capital of the Wielkopolska Region, Poznań. In Szczecin, the trend was almost constant, both for planted and removed trees. The number of planted shrubs in the selected cities over the last 15 years was higher than the number of shrubs removed. In Wrocław, we recorded the greatest downward trend in plantings of shrubs, but each year this number was higher than the number of removed shrubs. In Poznań, we observed the overall upward trend for shrubs planted, but in 2012 and 2013 the number dropped to 43 pcs/km$^2$. The fewest shrubs planted and removed were observed in Szczecin: plantings did not exceed 50 pcs/km$^2$ and losses 20 pcs/km$^2$.

The subject of our study was also to analyse the extent of changes in the areas of green space in cities in relation to the built-up area. Figure 4 and Table 2 present the ratio of the area occupied by the designed green space to living space in the city. The largest area occupied by greenery compared to the residential area was recorded in Wrocław, where area occupied by greenery was almost three times larger. The lowest ratio of area occupied by green-

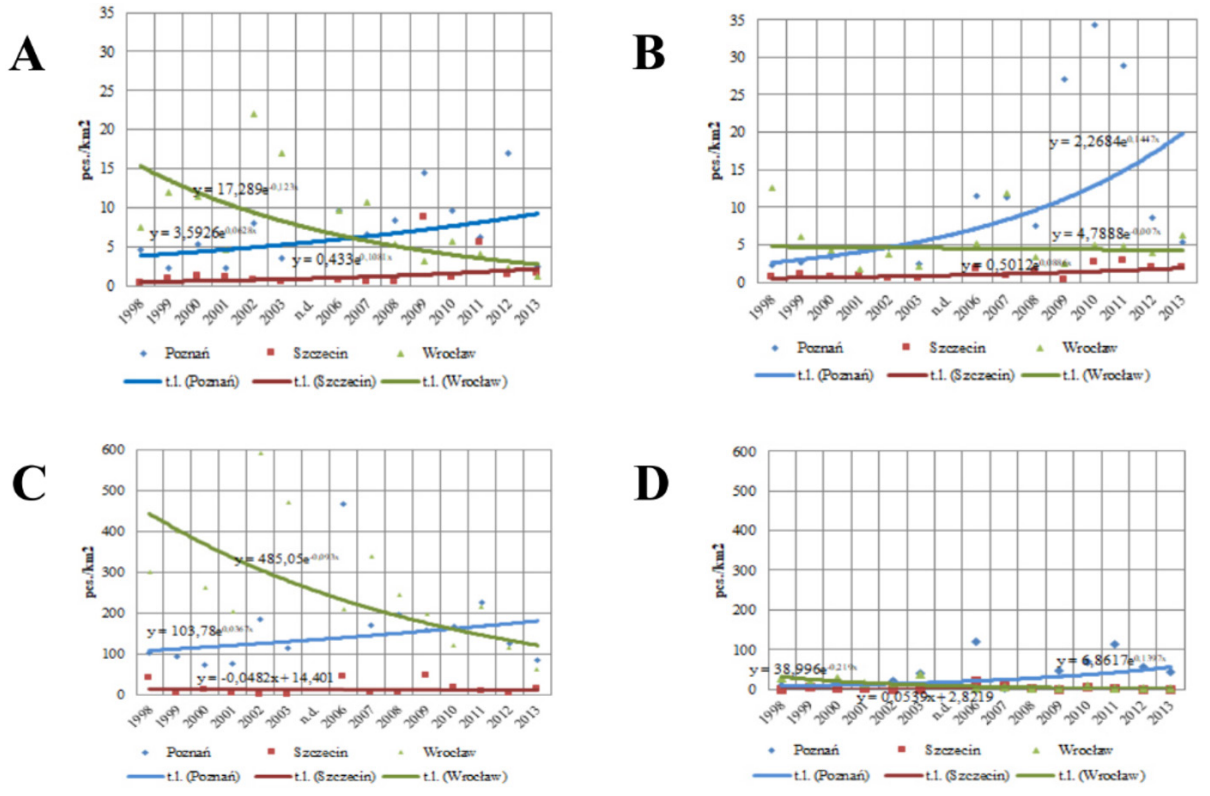


**Fig. 3.** Changes in the share of plantings and losses of trees and shrubs in selected cities
Explanation: A – planting of trees in cities; B – loss of trees in cities, C – planting of shrubs in cities; D – loss of shrubs in cities; t.l. – trend line
*Source:* Authors elaboration based on Central Statistical Office

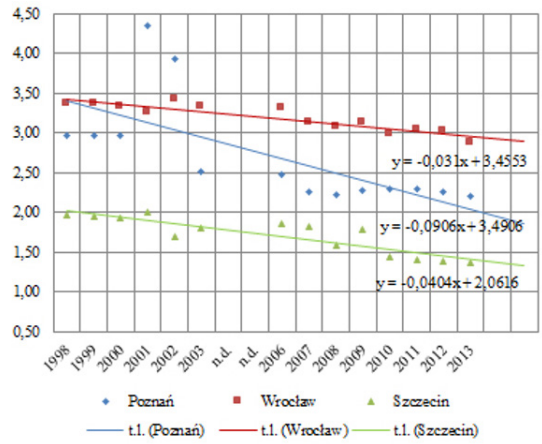


**Fig. 4.** The ratio of public green space to living space and trend of changes in public green space
Explanation: t.l. – trend line
*Source:* Authors elaboration based on Central Statistical Office

**Table 2.** T-value and p-value for the analysed variables

| | | | t-value | p-value |
|---|---|---|---|---|
| Fig. 2 | A | Poznań | **2.513** | **0.007** |
| | | Szczecin | **2.663** | **0.005** |
| | | Wrocław | **2.119** | **0.019** |
| | B | Poznań | **3.391** | **<0.001** |
| | | Szczecin | **6.441** | **<0.001** |
| | | Wrocław | **2.171** | **0.018** |
| | C | Poznań | **4.462** | **<0.001** |
| | | Szczecin | 0.735 | 0.233 |
| | | Wrocław | 0.362 | 0.359 |
| | D | Poznań | **2.394** | **0.010** |
| | | Szczecin | 0.866 | 0.195 |
| | | Wrocław | **1.712** | **0.046** |
| Fig. 3 | A | Poznań | 0.046 | 0.482 |
| | | Szczecin | **4.026** | **<0.001** |
| | | Wrocław | 0.607 | 0.275 |
| | B | Poznań | 0.985 | 0.167 |
| | | Szczecin | **5.487** | **<0.001** |
| | | Wrocław | **1.882** | **0.035** |
| | C | Poznań | **5.645** | **<0.001** |
| | | Szczecin | **1.781** | **0.048** |
| | | Wrocław | **6.684** | **<0.001** |
| | D | Poznań | **3.033** | **0.003** |
| | | Szczecin | **2.334** | **0.012** |
| | | Wrocław | 1.245 | 0.112 |
| Fig. 4 | | Poznań | **2.093** | **0.021** |
| | | Szczecin | **2.463** | **0.009** |
| | | Wrocław | **1.794** | **0.048** |

*Source:* Authors calculations

ery in relation to buildings was noted in Szczecin, where in the years 2010–2013 it did not exceed 1.5. The least favourable situation was observed in Poznań, where the share of green space in relation to built-up area was the lowest. In the years 1998–2000, the ratio ranged around 3, in 2013 it fell to 2.2. This adverse situation is undoubtedly caused by an increased number of trees removed in relation to newly planted trees. An additional cause consisted in the rapid expansion of housing. The results show that there is too little investment associated with greenery in Poznań.

### 3.2. Survey analysis

A total of 600 individuals were asked to participate in the survey (200 questionnaires in each of the studied cities), of which 413 persons (68.83% of those asked) agreed to take part: 141 persons in Poznań (70.5% of those asked), 148 persons in Wrocław (74.00% of those asked) and 124 persons in Szczecin (62.00% of those asked) (Table 3).

An unfavourable demographic situation was observed in the studied cities, where over the 15 analysed years the number of inhabitants declined (Table 3). The highest decrease in population numbers was observed in 2013 in Poznań - by as much as 5.22% as compared to 1998. In the case of Szczecin, the decline of population was 2.11%, and in Wrocław only 0.91%. These data indicate that the largest outflow of urban residents was observed in the years 2004–2008. The highest negative rate of population growth compared to the previous year was noted between 2004 and 2008 in Poznań. It ranged from -0.51% in 2005 to -0.71% in 2007. A growth of population was recorded in the counties around the cities studied. In 2010, Wrocław county demonstrated the highest population growth compared to the previous year—6.77%. The demographic situation in big cities of Western Poland is undoubtedly caused by the rapid development of neighbouring municipalities followed by migration of people from the cities to the surrounding counties, as evidenced by the data presented in Table 4.

The conducted survey revealed that those who changed their place of residence to the neighbouring communes decided to do that mainly because of lower prices of real estate (34% of respondents),

**Table 3.** Socio-economics of the survey's participants

| Variables | | Cities in western Poland | | | | | |
|---|---|---|---|---|---|---|---|
| | | Poznań | | Wrocław | | Szczecin | |
| | | n | % | n | % | n | % |
| Age | < 18 | 14 | 9.9 | 16 | 10.8 | 16 | 12.9 |
| | 18-24 | 21 | 14.9 | 23 | 15.5 | 23 | 18.5 |
| | 25-34 | 25 | 17.7 | 27 | 18.2 | 25 | 20.2 |
| | 35-44 | 26 | 18.4 | 26 | 17.6 | 21 | 16.9 |
| | 45-54 | 21 | 14.9 | 13 | 8.8 | 13 | 10.5 |
| | 55-64 | 13 | 9.2 | 17 | 11.5 | 11 | 8.9 |
| | 65-74 | 15 | 10.6 | 18 | 12.2 | 9 | 7.3 |
| | > 75 | 6 | 4.3 | 8 | 5.4 | 6 | 4.8 |
| Gender | male | 79 | 56.0 | 82 | 55.4 | 69 | 55.6 |
| | female | 62 | 44.0 | 66 | 44.6 | 55 | 44.4 |
| Monthly income (PLN) | < 1000 | 14 | 9.9 | 13 | 8.8 | 17 | 13.7 |
| | 1000-2000 | 31 | 22.0 | 28 | 18.9 | 19 | 15.3 |
| | 2001-3000 | 34 | 24.1 | 41 | 27.7 | 28 | 22.6 |
| | 3001-4000 | 26 | 18.4 | 28 | 18.9 | 21 | 16.9 |
| | 4001-5000 | 14 | 9.9 | 10 | 6.8 | 11 | 8.9 |
| | > 5000 | 4 | 2.8 | 3 | 2.0 | 5 | 4.0 |
| | no answer | 18 | 12.8 | 25 | 16.9 | 23 | 18.5 |
| Education level | basic education | 7 | 5.0 | 6 | 4.1 | 9 | 7.3 |
| | incomplete secondary education | 17 | 12.1 | 16 | 10.8 | 21 | 16.9 |
| | complete secondary education | 65 | 46.1 | 62 | 41.9 | 41 | 33.1 |
| | university or higher | 52 | 36.9 | 64 | 43.2 | 53 | 42.7 |
| Occupation | self-employed | 23 | 16.3 | 25 | 16.9 | 18 | 14.5 |
| | employed | 46 | 32.6 | 43 | 29.1 | 38 | 30.6 |
| | other active occupation status | 15 | 10.6 | 7 | 4.7 | 7 | 5.6 |
| | unemployed | 6 | 4.3 | 8 | 5.4 | 14 | 11.3 |
| | student | 21 | 14.9 | 28 | 18.9 | 23 | 18.5 |
| | retired | 28 | 19.9 | 31 | 20.9 | 19 | 15.3 |
| | other no active status | 2 | 1.4 | 6 | 4.1 | 5 | 4.0 |
| Children | yes | 73 | 51.8 | 79 | 53.4 | 69 | 55.6 |
| | no | 68 | 48.2 | 69 | 46.6 | 55 | 44.4 |
| **TOTAL** | | **141** | **100.0** | **148** | **100.0** | **124** | **100.0** |

*Source:* Authors calculations

proximity and accessibility of public green spaces (31% of respondents), comfort of living, associated with dispersed housing development and the possibility of having a garden (21% of respondents), as well as good communication (14% of respondents). Surveys show that cities need action to prevent emigration to the surrounding municipalities (Table 5).

## 4. Discussion

Our study indicates that the area of green spaces in relation to the built-up area in the biggest Western Polish cities is declining. A similar trend was described by Sepioł (2014), but more attention was paid to the different situation in Polish cities of different sizes. The analysis of demographic data and

**Table 4.** Changes in population and population growth factor in the studied cities and counties in the years 1998–2013

| Territorial unit | Years | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **1998** | **1999** | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** |
| Poznań (county) | 248672 | 256850 | 260518 | 264855 | 269380 | 274720 | 280924 | 288012 | 295039 | 303595 | 311390 | 319258 | 330245 | 337883 | 344752 | 352395 |
| change (%) | | 3.29 | 1.43 | 1.66 | 1.71 | 1.98 | 2.26 | 2.52 | 2.44 | 2.90 | 2.57 | 2.53 | 3.44 | 2.31 | 2.03 | 2.22 |
| Poznań (city) | 578235 | 584257 | 582254 | 579343 | 577117 | 574125 | 570778 | 567882 | 564951 | 560932 | 557264 | 554221 | 555614 | 553564 | 550742 | 548028 |
| change (%) | | 1.04 | **-0.34** | **-0.50** | **-0.38** | **-0.52** | **-0.58** | **-0.51** | **-0.52** | **-0.71** | **-0.65** | **-0.55** | 0.25 | **-0.37** | **-0.51** | **-0.49** |
| Szczecin (county) | 56769 | 58060 | 58589 | 59373 | 60098 | 61141 | 62479 | 63462 | 64785 | 66436 | 67937 | 69087 | 71135 | 72326 | 73333 | 74483 |
| change (%) | | 2.27 | 0.91 | 1.34 | 1.22 | 1.74 | 2.19 | 1.57 | 2.08 | 2.55 | 2.26 | 1.69 | 2.96 | 1.67 | 1.39 | 1.57 |
| Szczecin (city) | 416988 | 416791 | 416657 | 415748 | 415117 | 414032 | 411900 | 411119 | 409068 | 407811 | 406941 | 406307 | 410245 | 409596 | 408913 | 408172 |
| change (%) | | **-0.05** | **-0.03** | **-0.22** | **-0.15** | **-0.26** | **-0.51** | **-0.19** | **-0.50** | **-0.31** | **-0.21** | **-0.16** | 0.97 | **-0.16** | **-0.17** | **-0.18** |
| Wrocław (county) | 93482 | 94233 | 94925 | 95492 | 96786 | 98032 | 99511 | 100866 | 103548 | 106080 | 108386 | 111069 | 118593 | 121651 | 124509 | 127896 |
| change (%) | | 0.80 | 0.73 | 0.60 | 1.36 | 1.29 | 1.51 | 1.36 | 2.66 | 2.45 | 2.17 | 2.48 | 6.77 | 2.58 | 2.35 | 2.72 |
| Wrocław (city) | 637877 | 643522 | 640614 | 640804 | 639150 | 637548 | 636268 | 635932 | 634630 | 632930 | 632162 | 632146 | 630691 | 631235 | 631188 | 632067 |
| change (%) | | 0.88 | **-0.45** | 0.03 | **-0.26** | **-0.25** | **-0.20** | **-0.05** | **-0.20** | **-0.27** | **-0.12** | 0.00 | **-0.23** | 0.09 | **-0.01** | 0.14 |

*Source:* Authors calculations based on Central Statistical Office

**Table 5.** Questions asked in the survey

| Question | Answers | Cities in western Poland | | | Mean |
|---|---|---|---|---|---|
| | | Poznań | Wrocław | Szczecin | |
| 1. What caused the decision on changing the place of residence? | a. lower price of real estate | 40% | 27% | 35% | 34% |
| | b. proximity and accessibilityof public green spaces | 25% | 31% | 37% | 31% |
| | c. comfort of living | 22% | 30% | 12% | 21% |
| | d. transport connections | 13% | 12% | 16% | 14% |
| 2. Types of public green space noticed by inhabitants | a. parks | 29% | 35% | 41% | 35% |
| | b. squares | 21% | 25% | 23% | 23% |
| | c. greenery along streets | 18% | 13% | 14% | 15% |
| | d. greenery in residential areas | 32% | 27% | 22% | 27% |
| 3. Which type of public greenery is preferred the most? | a. parks | 54% | 53% | 51% | 53% |
| | b. squares | 19% | 21% | 23% | 21% |
| | c. greenery along streets | 13% | 11% | 9% | 11% |
| | d. greenery in residential areas | 14% | 15% | 17% | 15% |
| 4. Which type of public greenery is visited frequently? | a. parks | 32% | 33% | 26% | 30% |
| | b. squares | 23% | 19% | 26% | 23% |
| | c. greenery along streets | 22% | 9% | 13% | 15% |
| | d. greenery in residential areas | 23% | 39% | 35% | 32% |

*Source:* Authors calculations

survey results presented in this article demonstrate the negative effects of faulty urban space. The reduction of the green space area / living space area ratio in the studied cities results in the deterioration of the quality of life and, as a consequence, residents (especially young people) are looking for more attractive places to live, usually outside the city limits, often pointing to the need for proximity and availability of public green spaces or the possibility of having a garden. The analysis of statistical data showed a decrease in the area of green spaces in relation to the built-up area, as well as declining population. The largest decline in both factors was observed in Poznań. It might have been caused by the excessive commercialization of urban space. Research conducted by Kotus (2006) proved that Poznań can be an example of a post-socialist city in which investors are too much involved in the formation of spatial structures. According to the author, the green areas, e.g. parks and squares, are intended for new retail and services investments, while undeveloped land is not used for the creation of public green space.

The phenomenon of urbanization of cities in Poland and in the world, and the consequent decline in the area of public green spaces in the twentieth century was an inevitable process. It seems that today, the authorities of large cities in Poland use neither the experiences of cities in developed countries, nor theory and research in the process of planning, what could help avoid mistakes that are frequently irreversible. An example of negative transformations can be seen in the analysis of changes in the structure of green spaces and spatial planning process over the last century in Porto (Madureira et al., 2011). The authors show a decrease in the area of public green spaces from 75.8% to 29.0%. At the same time, they underline the adverse and progressive fragmentation of green areas. In order to prevent uncontrolled development, most European cities use the concept of open space planning models (Maruani, Amit-Cohen, 2007). These models are designed to solve problems related to the conflict between the requirements of development and the needs of conservation of natural and cultural resources. Currently, a particularly useful element in the field of urban planning should be the valuation of the benefits that nature provides humanity with the so-called ecosystem services (Fisher et al., 2009). Using the concept of ecosystem services in decision-making, one should remember that every ecosystem provides many different services at the same time. It is therefore not possible to protect individual services because their availability depends

on functioning of the ecosystem as a whole, composed of many interdependent elements (Hassan et al., 2005; Robrecht, Lorena, 2011).

Many authors emphasize that green infrastructure is of great importance for sustainable management of urban space, given significant fragmentation of green areas and the limited re-sources of available land. This kind of infrastructure is a proven tool for strategic planning (Ahern et al., 2014), and it can be used to improve urban green areas by creating new or revitalising degraded ecosystems in the metropolitan area (Tzoulas et al., 2007). An important place in planning in the cities of Western Europe is taken by the concept of urban agriculture. It has a positive effect on the potential of public green space in urban areas. Additionally, it is financially and organizationally supported by the authorities of, among others, Paris, Vienna, Stuttgart and the Ruhr (Mougeot, 2000; Giecewicz, 2005; Steinbuch, 2012). A significant role in the greening of Polish cities modelled on western European and US cities should also be palyed by social participation (Wagner, Caves, 2012) and the support for residents' initiatives, especially in the form of green courtyards or social gardens (Okvat, Zautra, 2011; Drake, Lawson, 2015). Land Use Plans for all three analysed cities support the protection of existing public green systems and assume their enlargement, especially in the field of protective, recreational and sports functions (Wrocław Land Use Plan, 2010; Szczecin Land Use Plan, 2012; Poznań Land Use Plan, 2014). However, the development of the urban transport network and municipal infrastructure contributes to reduction of greenery— often treated as a reserve of investment areas (Urbański et al., 2009).

## 5. Conclusions

1. The largest fluctuations in the area occupied by green spaces in relation to city area was found for walking and recreational parks. This kind of area increased in Wrocław but declined in Poznań.
2. An increase in the area occupied by street vegetation was recorded for all three cities.
3. The results clearly indicate a negative trend concerning trees and shrubs planted and removed over the 15 analysed years. In Poznań, more trees are removed than planted, and in Wrocław fewer and fewer trees and shrubs are planted while the number of trees removed is constant.
4. During the period considered in the study, the proportion of green spaces significantly decreased in relation to the residential area in all analysed cities. The highest greenery/residential buildings ratio was recorded in Wrocław (approx. 3), and the lowest in Szczecin (<1.5).
5. In the context of this research, it is necessary to establish the appropriate proportion of public green areas to urban areas. It also seems necessary to develop appropriate legislative processes, obliging investors to plant trees in the number dependent on the cubature of their buildings with plant species adequate for the habitat. These provisions should be strictly enforced.
6. Particular attention should be paid to sustainable urban development and the integration of investments related to the introduction of greenery and construction projects.

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