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Long term changes in plant species composition in urban parks on the example of Łazienki Królewskie Park in Warsaw

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Abstract: Large, old parks such as Łazienki Królewskie Park are expected to be places for spending time in close-to-nature surroundings. In such cases floristic diversity can become a good qualitative measure of the park's naturalness changing in time. The aim of this study was to show changes in plant composition of lawns and undergrowth vegetation in woodlands against selected habitat factors, assessed using phytoindication methods, Analysis covered the period 1973-2010when the Park was subjected to an extensive management of woodlands and lawns. Intensive succession process also occurred. Woodlands expansion resulted in canopy density increase by 60%. Local habitat changes were also noticed. In the lawns the total number of plant species and their diversity remained unchanged, whereas in woodlands an increase was noted, which is unusual for urban parks. This condition should be described as a positive tendency, but only presuming that it might not be a constant process.

Key words: urban park, forest species, long term vegetation changes, floristical diversity

Introduction

Public urban parks are created and designed by human. They provide the city dwellers mostly with recreational and leisure services. Presence of rich in species green areas indirectly improves the quality of social and psychological functions of the park (Breuste 2004, Chaudhry, Tewari 2010), allowing the citizens to use diverse recreational opportunities expected to be available in the surrounding of natural areas (Olear et al. 2008). Recently an increasing interest in floristic richness of urban green spaces has been noted (Hermy, Cornelis 2000; Thompson et al. 2003; Stewart et al. 2004; Nakamura et al., 2005; Lundolm, Marlin 2006; Ali, Malik 2010; Lososová et al. 2011). Urban green areas are very diverse and very much dependent on the intensity of visitors' pressure (Lundolm, Marlin 2006). The main biodiversity hotspots are being created in places excluded from management and maintenance (Lososová et al. 2011). For moderately managed vegetation (e.g. lawns), dominated by few species, the accompanying plant species play a key role (Thompson et al. 2003). The difficulty of maintaining biodiversity in the parks is due to the fact that they were subjected to many alterations and were repeatedly redesigned in the past. Majority of the area remained unaffected, some patches were assigned new functions, others were becoming outmoded, e.g. the tennis courts located next to the new orangery in Łazienki, have been in recent times converted into a recreational lawn. Vegetation of the parks also undergoes spontaneous changes due to natural succession (Zipperer W., Zipperer C. 1992, DeCandido 2004). There are not many works describing the effect of visitors' pressure on the vegetation (Bhuju, Oksawa 1998, Pariente, Zhevelev 2007), however a significant population increase is being recorded in many cities and higher pressure on green areas (Cincotta et al. 2000, McKinney 2006). In Warsaw along with the population increase of 29,9%

in years 1970-2009, a constant decrease of green areas since 2005 has been recorded (GUS 2009). Although works describing long- term changes in vegetation (Zipperer W., Zipperer C. 1992, Loeb 1992, Bianco et. al. 2003, DeCandido 2004, Sikorska et al. 2009, Szumacher et al. 2011, Nagendra, Gopal 2011) are not sufficient to explain all changes occurring, they however contribute to preventing from some of the negative tendencies to occur. The aim of the study was to show the changes in species composition of lawns and herbaceous vegetation in woodlands within the Royal Łazienki Park during the period 1973-2010. These changes were analysed in conjunction with selected habitat factors.

Study area

Łazienki Królewskie Park is a green enclave of high biodiversity within an urban area and consists of 69.34 ha, located in the city center (Figure 1). It dates back to the 18th century and was founded in the area of former menagerie and forestland (Majdecki 1981). The park is adjacent to Trakt Królewski (al. Ujazdowskie). It's upper part (1/5 of total area) belongs to the mezoregion of the Warsaw Plain, whereas the eastern part (4/5 of area) is a part of the Middle Vistula River Valley. The border between the two regions is set with a 20 meter wide scarp, which also defines two landscape types: valley bottom and periglacial plains (Kondracki 2001). The park is located in the center of Warsaw Average annual temperature during investigated periods (1971-2000 and 2001-2010) was 8.05°C and 8.88°C, whereas the precipitation was 518 and 571 respectively (GUS 2011). The vegetation of the park consists mostly of lawns and also woodland patches of different age, which were formerly loose but today they form dense tree stands. A minority of the area is covered by hedges, ornamental plants or ruderal vegetation. Part of the upland area was excluded from the study due to the major modifications made on the habitat conditions. In this manner, at least some of the factors which might locally affect the composition of vegetation (traffic-related pollution or excessive trampling) were also eliminated.

Methods

In Łazienki Królewskie Park changes of species composition were examined in both lawns and woodlands, where only the undergrowth vegetation was taken into account. These types were selected because of their highest diversity. Moreover, lawns and the undergrowth, in contrary to the hedges and the canopy layer, better highlights spontaneous changes occurring within the vegetation patches. Plant species were recorded using Braun-Blanquet scale (Dzwonko 2007), but for further calculations relative cover was used (+ – 0,5% , 1 – 5%, 2 – 17,5%, 3 – 37,5%, 4 – 62,5%,5 – 87,5%). The first recordings were part of the research on park vegetation held in the Department of Environment Protection, WULS (Zimny et. al 1973) and then repeated in years 2004-2010. The 41 archival datasets were analyzed followed by 32 samples reflecting actual condition. Earlier samples were randomly distributed. In case of the present samples we tried to reach the same locations, and when it was impossible or the vegetation was destroyed, the sample location was rejected (fig. 1).
The number of samples collected in woodlands and lawns reflected their area percentage in the parks. Percentages of alien plants (*antropophytes*), native synantrophic (*apophytes*) and native non-synantrophic plants (*spontaneophytes*) were according to Mirek et al. (2002) and Zając et al. (1992). Species associated with old forests were listed after Dzwonko (2007). Species of different habitat types were according to Matuszkiewicz (2008). Ellenberg's indicator values for estimating habitat factors – light (L), temperature (T), continentality (K), moisture (F), reaction (R), and nutrients (N) were according to Ellenberg et al. (1991). Differences between the groups were calculated using one-way ANOVA and Tukey test for uneqal sample sizes at $p<0.05$ in Statistica 10. Vector maps of forested area from years 1945 and 2008 were created on the basis of Warsaw orthophotomap (http://www.um.warszawa.pl) by digitalizing area covered by forest patches of a diameter exceeding 5 m.

Results

In years 1973-2010 the total number of plant species in lawns remained unchanged, where in woodlands it increased significantly. No change in number of native species was observed in the lawns, but the number

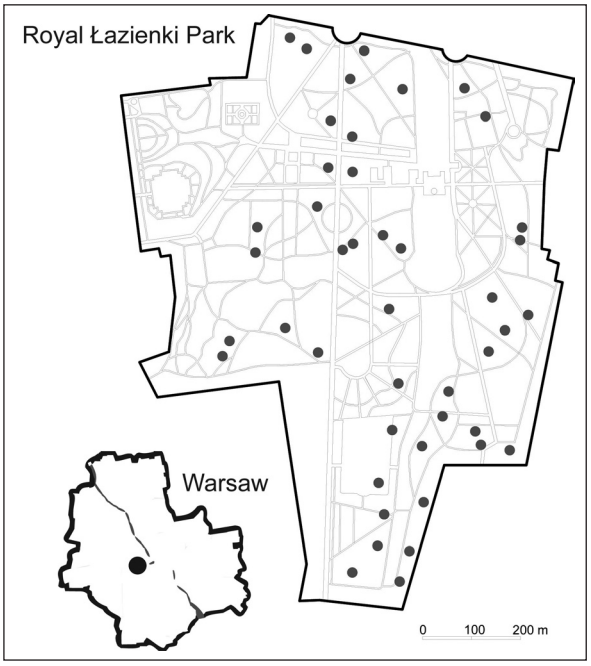

Fig. 1. Study area- Łazienki Królewskie Park and locations of phytosociological relevés firstly performed in 1973 and repeated in 2008-2010

of apophytes increased significantly (fig 2.). It is a small change, but when these species were hardly present at all in 1973, they are now recorded in nearly every patch, these are mostly: *Stellaria media, Veronica serphylifolia* and *V. polita*. In the woodlands there was an increase of the number of non-synantrophic plants, mostly consisting of forest species, including the "old forest" species. Also an increase of number of alien species was recorded, but similarly to lawns it was not significant.

The biggest changes within sociology-ecological groups of plants were recorded in woodlands. A clear increase of species associated with nutrient-rich forests (*Querco-Fagetea*), along with a loss of species connected with meadows (*Molinio-Arrhenatheretea*). Also an increase of species of edges (*Artemisietea*) was significant. Percentage of annual and biennial plants forming ruderal plant communities (*Stellarietea*) remained at similar level.

Changes of Ellenberg indicator values, indirectly reflecting habitat changes, were not significant. It can be assumed that changes in light, temperature, moisture, reaction and nutrient availability which occurred in areas dominated by grassland vegetation, were not important for the plants. Significant differences however were found in woodlands, where a decrease of species characterized by high level of nitrogen (N), light (L), and moisture (F) was recorded. The only increase was for the index describing the number of species preferring warmer conditions.

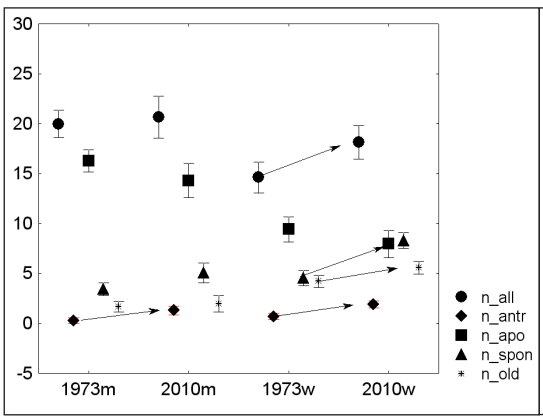

Fig. 2. Comparison of number of species of lawns and woodlands, arrows indicate significant differences at p<0.05; n_all – total number of species, n_antr- number of alien species, n_apo – number of native synantropic species, n_spon – number of native nont-synantropic species, n_old – number of "old forest" species

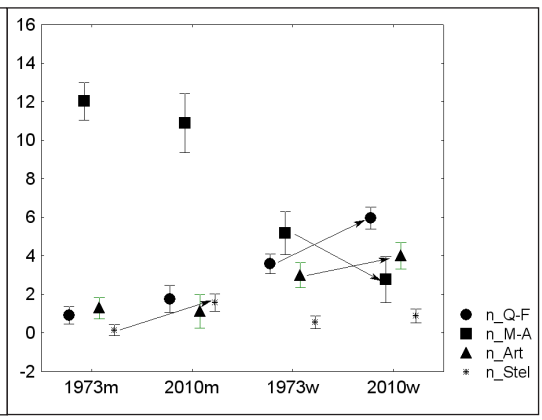

Fig. 3. Comparison of species characterisctic for selected phytosociological groups in lawns and woodlands, arrows indicate significant differences at p<0.05, n_Q-F – number of species belonging to Querco-Fagetea class, n_M-A – number of species charactersistic for wet meadows belonging to class Molinio-Arrhenatheretea, n_Art – number of species from stable ruderal communities, n_Stel – number of species from unstable ruderal communities

There were major changes that occurred within woodlands. The area covered by trees was 39.2 ha in 1945 and increased to 53.2 in 2010, thus the tree cover increased by 61.7%.

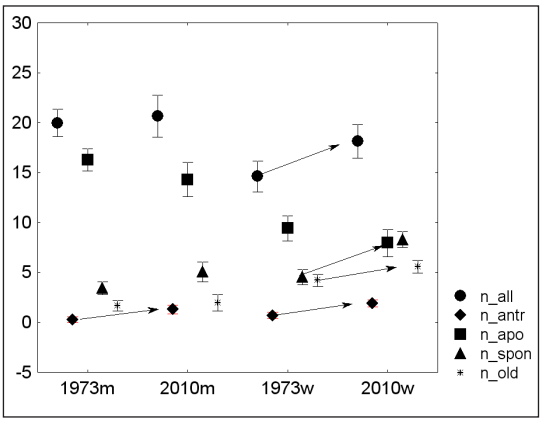

Fig. 4. Comparison of average Ellenberg indicator values for lawns and woodlands, arrows indicate changes statistically significant at p<0.05; habitat conditions indicators: n_L – light, T- temperature, n_F- moisture, n_R- reaction, n_N- nutrients

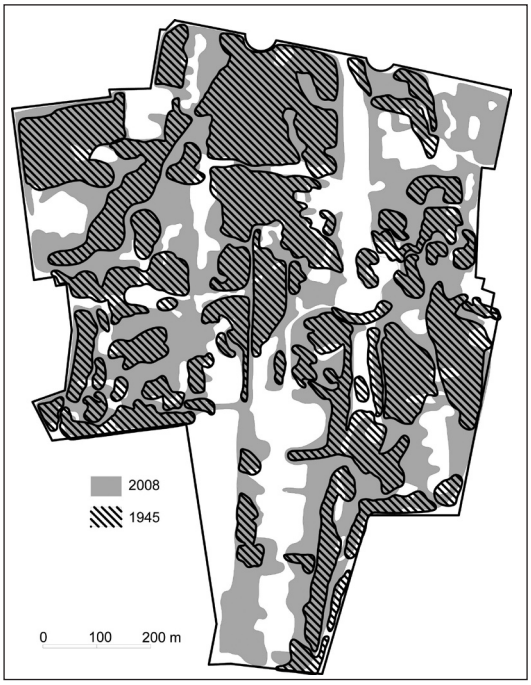

Fig. 5. Comparison of the range of forested areas in 1945 and 2008

Discussion

The recorded increase in number of species in an urban park during last decades is not only unique in the scale of Warsaw (Sikorski, data not yet published) but also in most analyzed parks around the world (Zipperer W., Zipperer C. 1992, Bianco et al. 2003, DeCandido 2004, Sikorska et al. 2009). Species impoverishment has been observed within the whole cities, which makes this phenomena alarming (Sudnik- Wójcikowska 1998, Godefroid 2001). Most recommendations for proper management practices of the big, old parks usually focus on their biodiversity. The older and bigger is the park, the higher its taxonomic richness (Fernández-Juricic 2000, Maurer i in. 2000, Giuliano et al. 2004, Weifeng et al. 2006). Maintaining high floristical diversity in parks usually means limiting visitor's pressure and extensive management of both woodlands and lawns.

Łazienki Królewskie Park was opened to public in the 1920s and the number of visitors has been growing ever since. For this reason at the very beginning of the park security fences and hedges needed to be applied to prevent from extensive trampling and vegetation damage (Lisowski 1956). Most of them remained until today. Trampling of lawns is also banned in legal park regulations.

No doubt that the unmanaged or extensively managed woodland patches maintained or even increased the coverage of species associated with forests and "old forest" species. The main biodiversity source in the city are the areas excluded from intensive pressure and management (Lososová et al. 2011). The impoverishment of grassland communities is accompanied by the increase of number of forest plants and plants associated with edge communities from Artemisietea class. Although the woodlands are rather socially accepted to be excluded from direct access however in case of lawns, there are many arguments about the entry to lawns and their recreational use. For many years the access for visitors had been spatially limited, afterwards it was fully banned to be recently resumed in a local scale, due to strong public pressure,

For moderately the lawns, dominated by only few species of grasses, the accompanying plant species play a key role (Thompson et al. 2003). When they disappears they are replaced by other cosmopolitan terophytes which is considered to be a negative process. Fortunately the scale of this phenomena in Łazienki Park is not significant. A decreasing number of nitrophilous plants and constant number of acidophilic plants is against

Jims's statements (1998), who suggests that more nutrients and acidification can be relayed to trampling. The results above would mean that in Łazienki Park less intense soil degradation took place. Research held on selected soil parameters held In years 1972-2001 shows minor reaction decrease from 6.4 to 5.6 and average humus content increase from 1.4 to 2.9%. The distinguished humus horizons do not differ from the ones developed in natural conditions. Variability of average lead and carbonates content differs in time which points at a poor balance between the inflow, transportation of these substances. Despite soil transformations due to management and maintenance measurements and to strong visitors' pressure, Łazienki Park became an enclave of quasi-natural soils in urban ecosystems, which were at first developed under the influence of natural and then anthropogenic factors, which resulted in slow decline of natural relationships between its characteristics (Malinowska, Szumacher 2011). Such parks are the remaining forest habitats in a disturbed urban landscape characterized by high amount of nutrients in comparison to the suburban and rural areas (Zhang 2004, Scharenbroch 2005).

Decreasing number of light favoring plants is certainly a result of canopy density increasing. This phenomenon is recorded in many natural parks and is often connected with negative tendencies occurring within species variability (Zipperer W., Zipperer C. 1992, DeCandido 2004). Loss of species connected with wetter habitats can be an effect of general process of the cities drying or local groundwater level decrease (Szumacher 2002).

Research done all over the world indicate that management of vegetation in parks of high biodiversity should be based on their management plans, whose implementation is always complicated (Alvey 2006, Weifeng et al. 2006, Jim, Chen 2009). Knowing process the park vegetation undergoes under progressing anthropogenic pressure is crucial. Its implementation to the management plans can decide on the matter if Łazienki Królewskie Park or a similar one will suffer from similar negative tendencies in the nearest future.

References

Ali S.M., Malik R.N., 2010, Vegetation communities of urban open spaces: Green belts and parks in Islamabad city, Pakistan Journal of Botany, 42, 1031-1039.

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

Bhuju D.R., Oksawa M., 1998, Effects of nature trials on ground vegetation and understorey colonization of a patchy remnant forest in an urban domain, Biological Conservation, 85, 123-135.

Bianco P.M., Fanelli G., Tescarollo P., Pignatti S., 2003, Ruderalization in a Roman Park as a Result of Changing Management, Urban Habitats, 1, 3-19.

Braun-Blanquet J., 1964, Pflanzensoziologie, Springer Verlag, Wien, New York.

Breuste J.H., 2004, Decision making, planning and design for the conservation of indigenous vegetation within urban development, Landscape and Urban Planning, 68, 439-452.

Central Statistical Office (GUS) 2011, Concise statistical yearbook of Poland, Zakład Wydawnictw Statystycznych, Warszawa.

Chaudhry P., Tewari V.P., 2010, Managing urban parks and gardens in developing countries: a case from Chandigarh India, International Journal of Leisure Tourism Market, 1, 248-256.

Cincotta R.P., Wisnewski J., Engelman R., 2000, Human-population in the biodiversity hotspots, Nature, 404, 990-992.

DeCandido R., 2004, Recent changes in plant species diversity in urban Pelham Bay Park, 1947–1998, Biological Conservation, 120, 129-136.

Ellenberg H., Weber H., Düll R., Wirth V., Werner W., Paulissen D., 1991, Zeigerwerte der Gefässpflanzen in Mitteleuropas, Scripta Geobotanica, 18, 1-166.

Fernández-Juricic E., 2000, Bird community composition pattern in urban parks of Madrid: The role of age, size and isolation, Ecological Research, 15, 373-383.

Giuliano W.M., Accamando A.K., McAdams E.J., 2004, Lepidoptera-habitat relationships in urban parks, Urban Ecosystems, 7, 361-370.

GODEFROID S., 2001, Temporal analysis of the Brussels Flora as indicator for changing environmental quality, Landscape and Urban Planning, 52, 203-224.

Jim C.Y., Chen W.Y., 2009, Diversity and distribution of landscape trees in the compact Asian city of Taipei, Applied Geography, 29, 577-587.

Kondracki J., 2002, Geografia regionalna Polski, Wydawnictwo Naukowe PWN, Warszawa.

Lisowski H., 1956, Zieleń Warszawy. Sport i Turystyka, Warszawa.

Loeb R.E., 1992, Long-term human disturbance of an urban park forest, New York City, Forest Ecology and Management, 49, 293-309.

Majdecki L., 1981, Historia ogrodów, PWN, Warszawa.

Malinowska E., Szumacher I., 2011. Spatial and temporal environmental changes of urban forested park – The Royal Łazienki Park in Warsaw example. In: Lechnio J. (ed.) Four dimensions of landscape. The Problems of Landscape Ecology. Vol. XXX. 157-168

Matuszkiewicz W., 2008, Przewodnik do oznaczania zbiorowisk roślinnych Polski, Wydawnictwo Naukowe PWN, Warszawa.

Maurer U., Peschel T., Schmitz S., 2000, The flora of selected urban land-use types in Berlin and Potsdam with regard to nature conservation in cities, Landscape and Urban Planning, 46, 209-215.

McKinney M.L., 2006, Urbanization as a major cause of biotic homogenization, Biological Conservation, 127, 247-260.

Mirek Z. Piękoś-Mirkowa H., Zając A., Zając M., 2002, Flowering plants and pteridiophytes of Poland, Biodiversity of Poland, 1, p. 442.

Nagendra H., Gopal D., 2011, Tree diversity, distribution, history and change in urban parks: studies in Bangalore, India, Urban Ecosystems, 14, 211-223.

Pariente S., Zhevelev H.M., 2007, Effect of visitors' pressure on soil and vegetation in several different micro-environments in urban parks in Tel Aviv, Landscape and Urban Planning, 83, 284-293

Scharenbroch B.C., Lloyd J.E., Johnson-Maynard J.L., 2005, Distinguishing urban soils with physical, chemical and biological properties, Pedobiologia, 49, 283-294.

Sikorska D., Sikorski P., Hewelke P., 2009, Disturbance duration in urban hydrogenic ecosystems due to drainage, Annals of Warsaw Agricultural University – SGGW, Horticulture, Landscape Architecture, 30, 207-216.

Sikorski P., Jackowiak K., Szumacher I., 2008, Interdisciplinary environmental studies in urban park as a basis for their sustainable management, Miscellanea Geographica, 13, 11-20.

Sudnik-Wójcikowska B., 1998, Czasowe i przestrzenne aspekty procesu synantropizacji flory na przykładzie wybranych miast Europy środkowej, Wydawnictwo Uniwersytetu Warszawskiego, Warszawa.

Szumacher I., 2002, Selected aspect of natural processes in urban Parks on the example of the Łazienki Park in Warsaw, Miscellanea Geographica, 10, 41-46.

Thompson, K., Austin, K.C., Smith, R.M., Warren, P.H., Angold, P.G., Gaston, K.J., 2003, Urban domestic gardens (I): putting small-scale plant diversity in context, Journal of Vegetation Science, 14, 71-78.

Weifeng L., Zhiyun O., Xuesong M., Xiaoke W., 2006, Plant species composition in relation to green cover configuration and function of urban parks in Beijing, China, Ecological Research, 21, 221-237.

Zając M., Zając A., 1992, A tentative list of segetal and ruderal apophytes in Poland. (Prowizoryczna lista apofitów segetalnych i ruderalnych w Polsce), Zeszyty Naukowe Uniwersytetu Jagiellońskiego. Prace Botaniczne, 24, 7-23.

Zimny H., Zimna J., Mędrzycka E., Wysocki C., 1973. Ecological report of Łazienki Royal Park (Ekspertyza ekologiczna Parku Łazienkowskiego), Maszynopis Katedra Ochrony Środowiska SGGW, Warszawa, 1-17.

Zipperer W.C., Zipperer C.E., 1992, Vegetation responses to changes in design and management of an urban park, Landscape and Urban Planning, 22, 1-10.