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The Ecological Diversity of Vegetation within Urban Parks in the Dąbrowski Basin (southern Poland)

Jarosław Banaszek, Marzena Leksy, Oimahmad Rahmonov

Faculty of Earth Sciences, University od Silesia in Katowice, 41-200 Sosnowiec, Poland
E-mails: banashek.jaroslaw@gmail.com; marzena.leksy@wp.pl; oimahmad.rahmonov@us.edu.pl

Abstract. The aim of this work is to present the diversity of flora in terms of ecological requirements. The research was conducted in the area of two urban parks in the area of two cities in southern Poland: Bedzin and Czeladz. These parks were established in different historical periods, and were planned (and are managed) differently. The results of the investigation have shown that the occurrence of 192 vascular species has been observed in the Gora Zamkowa (Castle Hill) Park, while in the Grabek park, 334 such species are known to exist. Such disparity is the result of the occurrence of micro-habitats and of the differences between the ways the two parks are managed. It is also due to these parks' different functions. In the first case, the park area is protected by law. In the latter case, human activity has created a new ecological niche for organisms with a high degree of ecological tolerance. Based on the ecological values, the following groups of plants were distinguished: saxifrages grasslands, xerothermic grasslands, beech forests, alder forests and artificial planted trees. Analysis has shown that urban parks are potential places for growth various type of vegetation and also for increasing biodiversity, and can constitute particularly important hotspots for biodiversity in the cityscape, even if their primary role is recreational. As the study shows, the environment of a highly urbanized and industrialized region can also have a positive influence on ecological and floristic diversity.

Keywords: habitat diversity, biodiversity, vegetation type, urban ecosystems, nature protection.

Conference topic: Environmental protection.

Introduction

City parks are a specific ecological system in urban areas and are most often considered as green spaces for recreational purposes. They are defined as delineated open space areas, mostly dominated by vegetation and water, and are generally meant for public use. City parks are usually large, but there also exist many smaller 'pocket parks'. City parks are usually locally defined (by authorities) as 'parks' (Konijnendijk *et al.* 2013). In recent times, ecological restoration within parks has also become an increasingly popular means of managing urban natural areas for human and environmental values (Gobster 2007).

In recent times, the interest in areas affected by human activity, especially city parks (especially with an emphasis on biodiversity), has also grown. Such research is conducted at various levels of biological organization, with the purpose of environmental protection and the promotion of floristic diversity (Savard et al. 2000). They pertain plant groupings and their diversity as it evolves in time and space (Banaszek et al. 2014; Dadić et al. 2014). For the most part, research is conducted at the species level, which makes it easy to monitor every aspect of flora (Farinha-Marques et al. 2011). Particular attention has been paid to this issue at many global environmental conventions such as the Report of the World Summit on Sustainable Development (2002), the 2007 Curitiba Declaration on Cities and Biodiversity (Sadeghian, Vardanyan 2013), and the Global Partnership on Cities and Biodiversity (2010) launched by the United Nations Environment Programme (UNEP 2012). Researchers have stated that urban parks, due to their often high levels of habitat diversity and microhabitat heterogeneity (different type ground), can constitute particularly important hotspots for biodiversity in the cityscape, even if their primary role is recreational (Cornelis, Hermy 2004).

Today, city parks are often created in areas changed by human activity and on artificially (anthropogenically)-created grounds composed of rocks of diverse origin, from various geological periods, and characterized by diverse chemical compositions (Rahmonov 2014). To a large extent, this contributes to the emergence of microhabitat mosaics which are inhabitated by species with varying ecological preferences, from algae to flowers (Czaja et al. 2014; Rahmonov et al. 2015). This is one of the most important causes of biodiversity in anthropogenic areas, including urban parks. By contrast, parks created in natural ecosystems feature fewer plant species, which is due to their stability and a smaller degree of human interference. The aim of this work is to present the diversity of flora in terms of ecological requirements in two different city parks in southern Poland.

Materials and methods

The research into the ecological requirements of plant species was conducted in two city parks: The Góra Zamkowa (Castle Hill) Park in Bedzin (area of approx. 6 ha, founded in 1801) and Czeladz (Grabek Park, area of 13 ha, established in 1960) lacated in the area of Silesian Voevodship (Fig. 1). Their origins were significantly different. The former was established on a limestone hill with fragments of a natural *Tillio-Carpinetum* forest, and its landscape is of natural origin. Grabek Park, on the other hand, was established as a result of recultivation of post-coal mine areas. It is an open light forest. Its areas included meadows that are regularly mowed. It is a landscape park with a developed network of paved walkways and serves a recreational purpose (walks, cycling, etc.). Because the two parks analysed herein are among the oldest in the studied area, it is possible to monitor and analyse the changes in their flora.

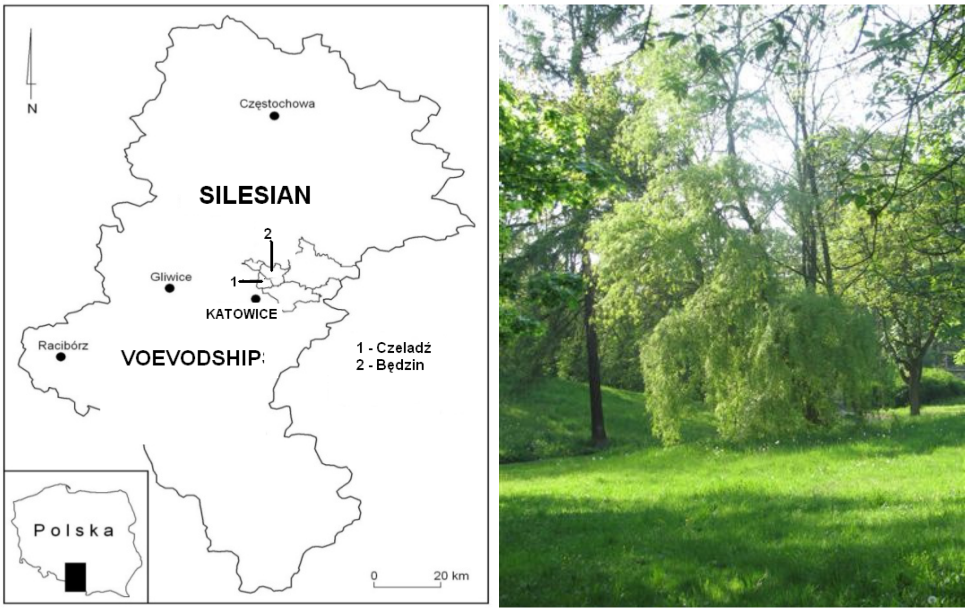

Fig. 1. The location of analysed objects in background of Silesian Voivodeship and fragment of Grabek Park

Geobotanical and floristic research was created in the parks concerned; in each of them, lists of plant species and habitat details have been established. Based on ecological indices (Zarzycki *et al.* 2002), species diversity was evaluated in ecological terms such as light (L), temperature (T), soil moisture (W), trophy (Tr), soil acidity (pH)- (R), soil granulometric composition (D) and life forms. The syntaxonomic affiliation of species was determined on the basis of Matuszkiewicz (2008).

Results and discussion

As a result of the floristic research conducted in the Castle Hill Park in Bedzin and in the Grabek Park in Czeladz, the existence of 192 flower plant species has been determined in the former, while 343 taxons have been found to exist in the latter. The largest number of taxa belongs to the Asteraceae, Poaceae, Fabaceae and Caryophyllaceae families. Such results were noticed in similirar habitat by other authors (Rahmonov *et al.* 2014).

This flora is composed of species originating from various biogeographical regions and having a high degree of ecological tolerance. Dendrochronological analysis on Castle Hill was conducted in 1995, which permitted the determination of the original composition and species selection of trees and bushes therein. In addition, the trees in the park have been classified into broad age groups, the first of which consists of "young" trees, of between 0–60 years of age (44.5% of the total). Older trees (between 61–100 years of age) account for 46.5% of the crop. As we can see, these two groups are overwhelmingly predominant in this area. Trees that are 101–130 years old account for only 8.6%, and only three trees older than 130 years were found, accounting for just 0.4% of the total (Banaszek *et al.* 2014).

With respect to the mosaic character of habitats in the area of the parks, the occurrence of species characterizing many syntaxonomic units is observed at the level of classes, orders and associations. Within classes, species belonging to *Querco-Fagetea, Quercetea robori-petraea, Vaccinio-Piceetea, Rhamno-Prunetea, Phragmitetea, Molinio-Arrhenatheretea and Festuco-Brometea* occur. The biological spectrum of the flora is composed of hemicryptophytes (Fig. 2) in each case. Flora is also represented by a number of orders (*Arrhenatheretalia, Molinietalia caerlueae, Epilobietalia angustifolii, Plantaginetalia majoris, Polygonion avicularis*) and associations (*Alno-Ulmion, Dicrano-Pinion, Pino-Quercion*).

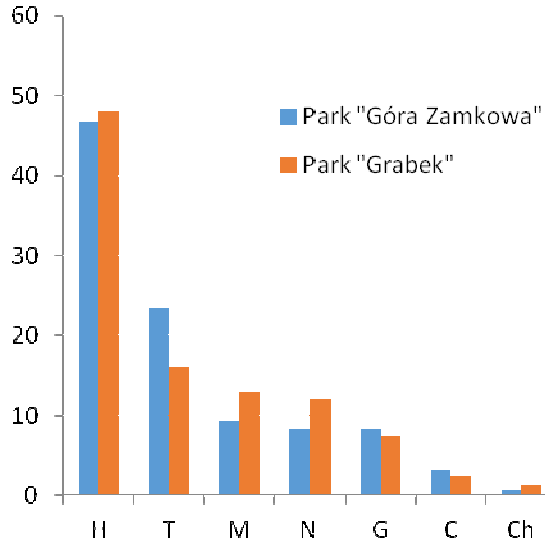

Fig. 2. Percentage share of plant life forms in the parks: M – megaphanerophytes, N – nanophanerophytes, Ch – woody chamaephytes, C – herbaceous chamaephytes, H – hemicryptophytes, G – geophytes, T – therophytes

Flora is also represented by a number of orders (*Arrhenatheretalia*, *Molinietalia caerlueae*, *Epilobietalia angustifolii*, *Plantaginetalia majoris*, *Polygonion avicularis*) and associations (*Alno-Ulmion, Dicrano-Pinion, Pino-Quercion*). Such diversity is mainly due to the micro-mosaic of habitats, as well as by the creation of artificial ditches and small ponds in the parks. On the other hand, species typical of alder forests, often with broad ranges of habitat requirements, were (for the most part) found among the artificially-planted trees in the Grabek Park.

Light. In terms of light requirements, the flora of the two parks doesn't diverge significantly (Fig. 3). In the Castle Hill Park, in the case of the plant species that require particularly good exposure to light, this is due to the sharp hillsides and other areas that are unavailable for human economic activity. Flora such as saxifrages grasslands (*Sedum acre, S. maximum, Jovibarba sobolifera*), xerothermic grasslands (*Festuca ovina, Vincetoxicum hirundinaria, Arenaria serpyllifolia*), and beech forests has been observed to develop in this area. In the Grabek park, species which have moderate or full light exposure requirements occur exclusively in the cleargins in the middle of the park.

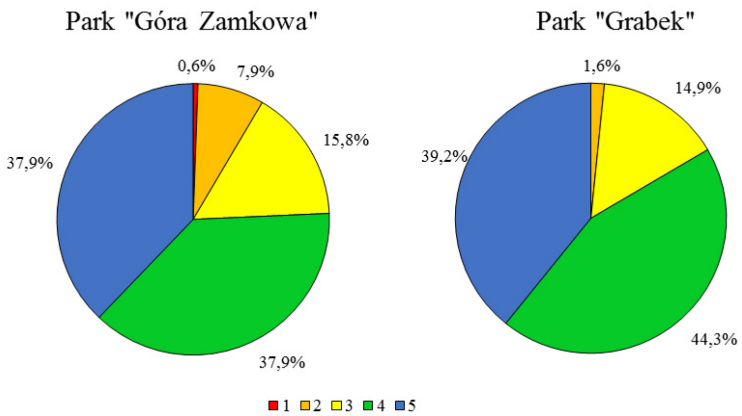

Fig. 3. The differentiation of species accordings to light requirement value:
1 – deep shade; 2 – moderate shade, 3 – half-shade, 4 – moderate light, 5 – full light

This includes the following species: *Agrostis capilaris, Acer campestre, A. platanoides, Betula pendula, Bellis perennis, Cardaminopsis arenosa, Carlina vulgaris, Epilobium hirsutum, Festuca rubra, Lathyrus pratensis*, with moderate light exposure needs and *Agrimonia eupatoria, Artemisia vulgaris, Bromus inernis, Centaurea scabiosa, Echium vulgare, Lepidium ruderale, Medicago falcata, Melandrium album, Oenothera biennis* and *Plantago major*, all of which have full light exposure requirements. The share of the various ecological groups in the flora of the two respective parks is shown in Figure 3.

Temperature. The flora studied in both parks is similar in terms of temperature requirements as well, which is evidently related to its light exposure requirements. Such a relationship is due to the large open areas and the great number of anthropogenic aquifugeous surfaces (paves, steps, playing grounds), which are potential habitats for eurythermic species, in those parks. The dominant species here, among the entire flora of both parks, are those adapted to moderately warm (47% and 48% of the flora in the Castle Hill and Grabek Parks, respectively) and moderately cool (34% and 32%, respectively) climatic conditions (Fig. 4). The first group includes species such as *Arabis hirsuta, Alchemilla monticola, Cerasus avium, Holcus lanatus, Malva neglecta, Populus alba, P.nigra* oraz *Saponaria officinalis*. On the other hand, among the species requiring moderately cool climatic conditions, are found, inter alia, *Acer pseudoplatanus, Fagus sylvatica, Ranunculus acris, Senecio viscosus, Sonchus arvensis, Tanacetum vulgare, Tilia cordata, Verbascum nigrum*.

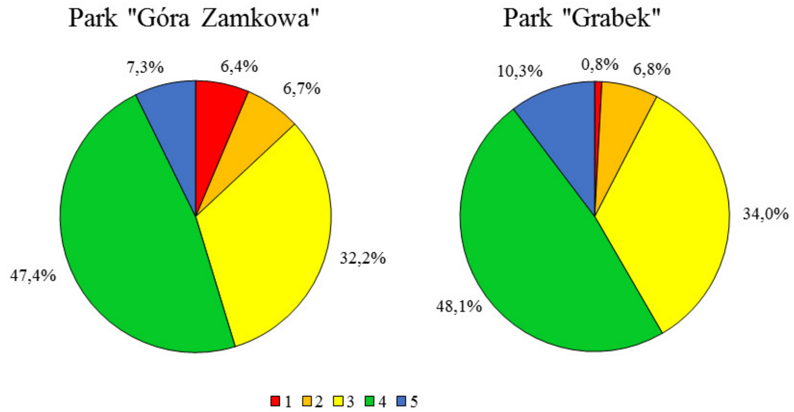

Fig. 4. The differentiation of species accordings to temperature requirement value:
1 – coldest regions in country; 2 – moderately cold areas; 3 – moderately cool climatic conditions;
4 – moderately warm climatic conditions; 5 – warmest regions and microhabitats

Soil moisture. Natural and anthropogenic factors determine the course of pedogenesis in both parks, which, in turn, influences the shaping of floral landscapes and the composition of flora in those areas. In the case of Castle Hill, as was mentioned earlier, environmental process occur more naturally than in Grabek Park, and in situ factors have influence over the development of ecological systems and the paedosphere's character. This manifests itself in the flora's diverse soil requirements, especially in terms of retention capacities (Fig. 5).

In Grabek Park, despite the lack of a very dry habitat, one can find a number of plants that normally flourish in dry environments (e.g. *Artemisia campestris, Corynephorus canescens, Cerastium arvense, Galium album, Potentilla argentea*). A small differences of soil humidity (W) between the two parks is due to the granulometric composition of the soil (D).

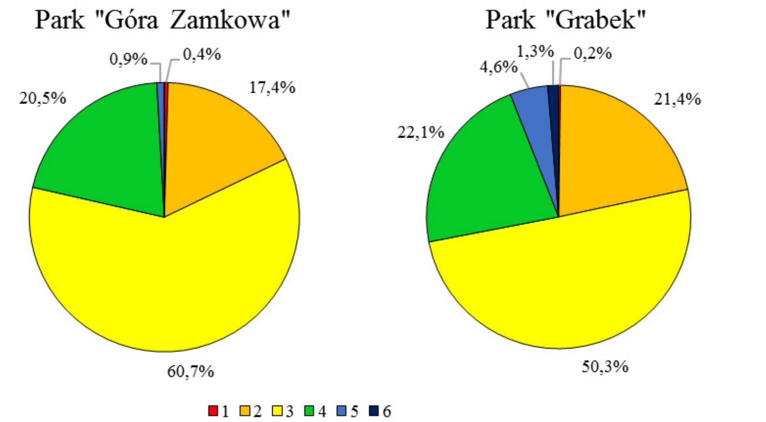

Fig. 5. The differentiation of species accordings to soil moisture requirement value:
1 – very dry; 2 – dry; 3 – fresh; 4 – moist; 5 – wet; 6 – aquatic

Granulometric composition. Although Grabek Park is situated in the floodplain of the Brynica river, large amounts of pebbly fractions and, as well as alluvial products, dominate the composition of its soil, with anthropogenic materials also present (Majgier *et al.* 2014). Thus, there is no significant difference among the humidity requirements of the two parks' flora. This similarity in soil composition and humidity requirements drives the diversity of the species in both areas. A large part of those present are species associated with debris (Fig. 6), scree, and gravel (*Sedum acre* and *Polypodium vulgare* accounting for 12.4% and 13%, respectively), with sand (*Artemisia absinthium, Berteroa incana*, *Calamagrostis epigejos, Festuca ovina, Trifolium arvense*, and *Viola tricolor*, at 26% of the total), argillaceous clay and dusty deposits (*Aegopodium podagraria, Anemone nemorosa, Arctium lappa, A. minus, Cerastium glomeratum*), and those associated with heavy clay and loam (*Alnus glutinosa, Alopecurus pratensis, Atriplex patula, Briza media, Cardamine pratensis*). The deferentiation of granulometric composition showed Figure 6.

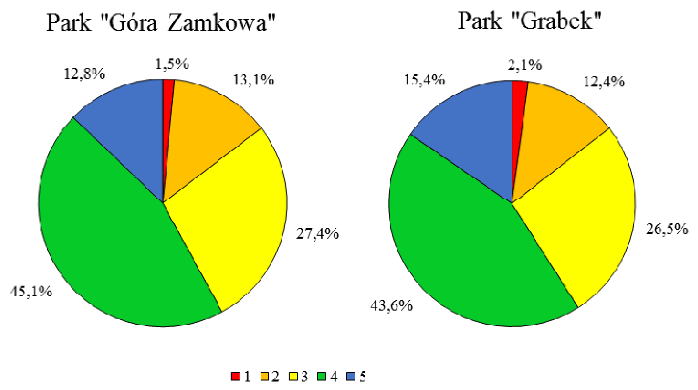

Fig. 6. The differentiation of species accordings to soil granulometric requirement value:
1 – rocks and rock crevices; 2 – rock debris, scree, gravel; 3 – sand; 4 – argillaceous clay and dusty deposits;
5 – heavy clay and loam

Generally speaking, species associated with rich or very rich soil dominate in both parks (Fig. 7). The fertility of the soil surface in the Castle Hill Park's case is due to the geological characteristics of the terrain, as well as the relatively fast weathering of the carbonates, at which time nutritional elements (easy to absorb for plants) contained therein are released. According to the World Reference Base for Soil Resources (WRB 2006), the soils of the Castle Hill Park area belong to *Lithic Leptosol* (Calcaric) and *Haplic Leptosol*, while according to US Soil Taxonomy (Soil Survey Staff 1999), they belong to *Lithic Haplrendolls* and *Typic Udorthens*, respectively.

In the Grabek Part area, the natural soil surface has been removed, and in its lieu, new material with a large quantity of humus has been emplaced, which is why it is inhabitated by species associated with rich soils. Among those frequently occurring here are: *Aethusa cynapium, Angelica sylvestris, Crepis biennis, Centaurea jacea*, and *Glechoma hederacea*. Among the species associated with very rich soils, it is worth mentioning: *Galium aparine, Humulus lupulus, Lactuca serriola, Malva neglecta, Urtica dioica, U. urens, Tanacetum vulgare, Artemisia vulgaris, Poa campressa* and others.

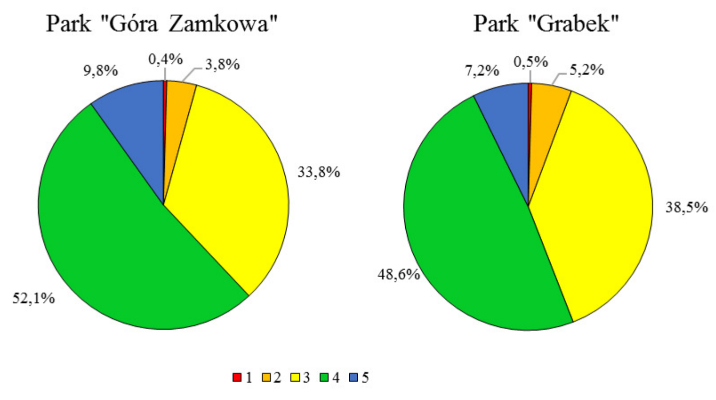

Fig. 7. The differentiation of species accordings to trophy requirement value:
1 – soil extremely poor (extremely oligotrophic); 2 – soil poor (oligotrophic);
3 – soil moderately poor (mesotrophic); 4 – soil rich (eutrophic); 5 – soil very rich (extremely fertile)

According to WRB (2006) and US Taxonomy (Soil Survey Staff 1999), the following soil types can be distinguished here: Haplic Flivisol, Typic Udifluvents, Gleyic Phaeozem, Typic Haplrendolls, Hortic Anthropol, Technic Regosol, Typic Udarents, Urbic Technosols, Typic Udarents and other different soil units of contaimined soil. This explains the diversity of species in such a small area (Rahmonov 2016).

The reaction (pH) of the soil in the Castle Hill Park area is, in large part, caused by the soil's base, made up of limestones. Its flora is dominated by plant species adapted to a neutral reaction of 54% or 50% (Fig. 8), such as *Bromus hordeaceus*, *Fraxinus excelsior, Galeopsis tetrahit, Hypericum perforatum, Lathyrus pratensis, Leontodon hispidus, Melilotus officinalis, Prunella vulgaris* and *Stachys palustris*, as well as those adapted to an alkaline reaction of 26% or 8%, such as *Atriplex patula, Cirsium oleraceum, Galium album, Ononis spinosa, Puccinellia dystans, Potentilla heptaphylla,* and *Vicia sepium*.

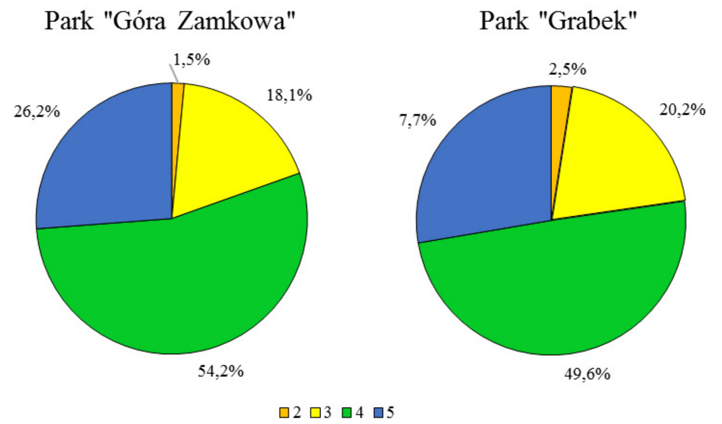

Fig. 8. The differentiation of species accordings to soil reaction requirement value:
2 – acidic soils, 4≤pH<5; 3 – moderately acidic soils, 5≤ph<6; 4 – neutral soils, 6≤pH<7; 5 – alkaline soils pH≥7

The pH diversity of the soil in the Grabek Park area, on the other hand, does not reflect the proper environmental conditions in this area, which is due to permanent human interference in this place. The process of mowing grass, by itself, affects not only soil pH and fertility, but also its compaction (Fig. 9). The flora here is, in large part, made up of species adapted to acidic soils (*Hieracium pilosella, Athyrium filix-femina, Pteridium aquilinum, Oxalis acetosela, Abies alba, Sorbus aucuparia, Xanthium albinum*) and moderately-acidic ones (*Anthoxanthum odoratum, Deschampsia caespitosa, Frangula alnus, Holcus mollis, Larix decidua, Malva sylvestris, Populus tremula, Salix caprea, Viola tricolor*).

Fig. 9. The fragment of xerophilous grassland in sotherrn slope of Gora Zamkowa park

The Dabrowski Basin area is part of the Upper Silesian conurbation – one of the most industrialized and urbanized areas in Poland and in all of Europe. A particularly environmentally-degrading role in this area was played by heavy industry, especially by coal, iron ore, zinc and lead ore mining, as well as the industries processing these resources (steel huts, coke plants, etc.). As industry developed in Upper Silesia and in the Dabrowski Basin in the 18th, 19th, and early 20th centuries (during which time they belonged to two different countries – Prussia and Russia, respectively), a massive immigration of workers needed by the local industry occurred. This forced a new organization in the cities, in full development at the time. It is here, in this areas, previously heavily affected by industry, that city parks were established, and already at that time, they became centres of biodiversity.

Conclusions

An important fact which bears mentioning is that the studied parks are important elements of flora diversity in the midst of highly urbanized areas. Nonetheless, such biodiversity must not be interpreted as an exclusively positive development. City parks, including the oldest ones, can also be centers of synanthropisation of the flora of the neighboring areas.

In terms of ecological requirements, the flora of the studied areas exhibits great similarities resulting from the presence of numerous micro-mosaic habitats and free ecological niches.

The flora's propensity for change is due to the nature of the terrain (hills with steep sides, rocks), as well as the terrain's human use. Flat surfaces are frequently cared for. The sport and recreational function of these parks significantly affects the flora's character, composition, and other aspects.

The Castle Hill Park in Bedzin can be classified among forest-sward areas, whereas Grabek Part is of the park-forest type. The flora of both includes some very rare species, including some that are subject to strict or partial legal protection. Xerothermic grasses dominate inn open areas and in the inaccessible parts of Castle Hill, while in the areas accessible to tourists and to strollers, grasses are regularly mowed, as they are in Grabek Park.

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