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STUDY OF VEGETATION COVER AS A TOOL FOR BIODIVERSITY PROTECTION IN URBAN AREAS

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Abstract

In accordance with the principle of sustainable development, contemporary trends in the development of Urban Natural Systems involve: indicating areas which perform environmental functions, preserving connectivity between them, and establishing connection between these areas and the regional and national systems of ecological structures. Completing these steps is the only way to preserve the sustainability of ecological structures and their self-regulating capacities, pivotal qualities for ever-changing urban conditions. The aim of this work is to analyse the vegetation cover of Świdnik – a dormitory town for the capital city of the Lublin Province – and prepare an index of plants which, if introduced in a thought-out and consistent way, can enhance its biodiversity. Such framework would, first and foremost, help to protect the natural environment, and secondly, outline appropriate guidelines for urban vegetation development. Two methods have been chosen to identify the vegetation resources of Świdnik. The first one is closely related to spatial planning process – an ecophysiographic study, and the other one to specialist studies – phytosociology, (i.e., the analysis of vegetation cover in the spatial complexes of Świdnik). The ecophysiographic study identified strategic areas for the development of the Urban Natural System, as well as the preferable direction of its development. The vegetation cover analysis has shown what qualities should be taken into account when creating an individual index of plant species for particular urban units.

Keywords*: Vegetation cover, Biodiversity, Urban Natural System, Świdnik*

Introduction

Recent years have seen a significant change in the perception of green areas which, apart from having a beneficial impact on the comfort of living and human health, should also constitute potential zones for the protection of urban diversity [1, 2]. In the time of urbanization pressure and appropriation of important natural areas, there arises an increasingly widespread need to protect natural and man-made ecological corridors which provide proper habitat connectivity and become refuges for many groups of species (including nectar source taxons), as well as wasteland zones constituting biotope for many diverse plant communities [3-5].

Nowadays, there are two main methods of developing urban greenery. The first one relies on using "fashionable" vegetation which provides a pleasant visual effect; the second one promotes species-rich naturalistic vegetation. In Poland (Warsaw) or Hungary (Budapest) residents tend to choose "tidy" mowed lawns and popular plants from nurseries, which prove not to be entirely fit for local habitat conditions. Additionally, identical building styles and similar ways of developing surrounding area – using a small number of "fashionable" plant species – leads to the creation of similar types of phytocenoses [6]. Research conducted in North America (Michigan), Finland (Helsinki), Holland (Amsterdam), or Germany prove that

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for economic and ecological reasons as well as the need to commune with nature, residents are more likely to prefer naturalistic vegetation [7-10]. Among the advantages of naturalistic vegetation is its resilience to anthropogenic pressure, its natural range of distribution and wide selection, which prevents the creation of monocultures. Consequently, the research should encourage local authorities as well as potential real estate developers and designers to employ solutions which focus on indigenous plant species and avoid monoculture plant compositions. However, in order for the vegetation development to become significant for the protection of environment and raising the society's ecological awareness, each urban unit needs its own individual list of plant species.

The aim of this work is to analyse the plant cover of the town of Świdnik and prepare an index of plants (in the form of planning guidelines) which, if introduced in a thought-out and consistent way, could enhance the town's biodiversity. Such framework would, first and foremost, help to protect the natural environment, and secondly outline appropriate landscape development guidelines consistent with sustainable development principle.

Experimental

Materials

The analysis of the vegetation cover of Świdnik encompasses the area within the town's administrative boundaries, in accordance with obligatory planning and strategy development documents for particular urban units in Poland. In Poland the only planning document which is the basis for the complex evaluation of urban greenery is the Study of Conditions and Directions of Spatial Development. Unfortunately, the guidelines for the management of greenery included in the Study are often ignored by local spatial development plans. Is should also be stressed that there is a lack of any binding legal regulations regarding the development of flora.

Świdnik is a dormitory town for the capital city of the Lublin Province and its origins bring to mind Tony Garnier's idea of an industrial city. Functional and spatial structure of the town developed over a rather flat area of former fields and forests. A characteristic quality of the urban fabric was a block development principle with a network of intersecting streets. The integrating element was a line of park greenery (a dry valley stretching latitudinally) connecting three existing forest complexes and flood-meadows, thus creating the town's wedge-shaped Urban Natural System [11]. After the systemic transformation of 1989 the town's vegetation resources became depleted (woodland and agricultural land were reduced, park greenery was narrowed) which in consequence destroyed the connectivity between the green areas and led to the emergence of a scattered spatial system.

Świdnik is located on an upland area (Świdnik Plateau) made of permeable rock [12]. It is situated on a quite flat denudation plain composed of marlstone, with elevation difference of ca. 40 metres and an average slope between 3-5%. The area of Świdnik is dominated by pseudopodsols created from loess materials (sand, silty sand and sandy silt). In the east and south part, it can find luvisols made of loess materials deposited on calcareous substratum or slightly loamy sand. The soil is classified mainly as good wheat complex and very good wheat complex [13]. The town lies outside the network of Lublin Province protected areas and the only form of protection is one environmental use area and a Natura 2000 protected site (for a speckled ground squirrel *Spermophilus suslicus* colony) [14]. Moreover, Świdnik is included in the Ecological System of Protected Areas (ESOCh), which is a planning method of protection of the most valuable components of nature. It encompasses forest complexes and the vast dry valley stretching latitudinally [15, 16].

Methods

Urban landscape is a complex system and for it to be properly designed the levels of town organisation should be properly identified. The two methods which have been chosen to analyse vegetation resources of Świdnik are on one hand closely related to local planning process (spatial planning) – an ecophysiographic study, and on the other hand to specialist studies – phytosociology, i.e., the analysis of vegetation cover in the spatial complexes of Świdnik. The term – vegetation resources – has been treated as a component of vegetation cover

and an element of numerous spatial systems, including: Urban Natural System, greenery system and recreation system, which all developed due to urbanisation processes at the same time as the town.

Ecophysiographic study

An ecophysiographic study is a binding document but also a planning method whose structure and scope are established by the Regulation of the Minister of Environment on Ecophysiographic Studies of 9th September 2002 [17] and the Environment Protection Law Act of 27th April 2001 [15]. This work does not present a traditional ecophysiographic study, but five essential analyses set apart from it. They were prepared on topographic maps with the scale of 1:10,000 [18] on the basis of field studies and with the use of photogrammetric aerial images from 2016 and reports about the natural environment of Świdnik. The five analyses are as follows:

- *Analysis of land cover* involved designating areas in terms of their purpose;
- *Simplified analysis of ecotopes* (simplified analysis of the hypsometric layout) which took into consideration only the topographic conditions (without the cover). On the topographic map used for the analysis relief was presented by means of contour lines (isolines). The aim was to demonstrate how precipitation, wind or gravity cause migrations, thus showing mechanisms behind environmental processes;
- *Analysis of environmental structures.* Its aim was to designate ecological patches, corridors, nodes, islands and barriers, to indicate "strategic" spaces for urban greenery planning. The model used in the analysis has been the one of patch-corridor-matrix where the matrix is agricultural land [19];
- *Analysis of threats to natural environment.* The analysis has been conducted for five components of nature i.e., water, soil, air, flora and fauna. In terms of spatial interaction, the threats were divided into local, linear and area, and in terms of time – into current and potential;
- *Analysis of trends in environmental changes* is a summary of the previous four studies, i.e., a comparative analysis of land development (cover), ecotopes, natural structures and threats to natural environment. Its aim was: firstly, to indicate the reasons for degradation of the areas of the highest natural value, and secondly, to specify "possible opportunities" – areas which could improve the Urban Natural System (Polish: *SPM*) through a change in their current function or method of management.

Vegetation cover analysis

Field study of the vegetation cover were conducted in 2015 and 2016, between May and September. The starting point were topographic maps with the scale of 1:10,000 [18] and photogrammetric aerial images from 2016 [20]. Acting on the premise that plant communities create spatial complexes whose distribution is determined by the type of housing development and land use, the town area was divided into seven complexes of utilisation of space [21], i.e.:

- *Forest-and-meadow complex* – constitutes 21% of the town's area. It includes forests (Rejkowizna, Bażantarnia and the remains of Szpitalny) as well as hay meadows on the site of PZL Świdnik S.A.
- *Agricultural complex* – areas with dominating agricultural land in north-west, west, south and east part of the town. Constitutes 15.1% of the town's area.
- *Multi-family complex* (11.7% of the town's area) – it includes the oldest part of the town as well as contemporary housing estates, mainly high-density multi-family development (4-5 storey buildings with residential and commercial purposes).
- *Multi-family large-panel complex* – it includes a housing estate of 11-storey multi-family development (large-panel buildings). Constitutes 0.2% of the town's area.
- *Garden and single-family detached complex* – includes single-family detached buildings as well as summer houses, where each parcel of land constitutes a separate, enclosed plot. Takes up 20% of the town's area.
- *Industrial-transportation complex* – it includes industrial areas dominated by production facilities, warehouses, storage yards and road infrastructure. This type of complex occurs locally, linearly and superficially and constitutes 21.6% of the town's surface.

- *Mixed complex* – includes public green areas, i.e., parks, squares, cemeteries, recreational areas as well as neglected areas. They can often be situated on the border between different complexes. It constitutes 9.8% of the town's area.

Using the J. Braun-Blanquet's approach, 248 botanical inventories were created in particular categories of complexes [22]. Each patch underwent phytosociological analysis to the level of basic units, communities and alliances. The types of phytocoenoses were defined according to the W. Matuszkiewicz's nomenclature [23]. The list and characteristics of the species identified in particular patches included: taxonomy [24, 25], Raunkiaer's life form groups [26, 27], geographical-historical groups [28], type of life-history strategy, phenological state and flower colour [29, 30], type of habitat preferred by invasive species [31], as well as habitat type with respect to the degree of hemeroby [32].

Results and discussion

Land cover analysis has shown that there is a lack of a natural watercourse within the town limits, and that the town lies between two river basins (Bystrzyca and Stawek). The area serves primarily industrial and residential purposes, the two separated by a railway line running from east to west. Świdnik Regional Industrial Park (RPP), PZL Świdnik S.A. and Lublin Airport are located to the north of the railway line, and the residential district – to the south. To the south the town of Świdnik borders with a fragment of an expressway (S12) and the Krępiecki Forest, and to the west – with a fragment of a national road (S17). On the outskirts of Świdnik (in its north-west, west, south and east parts) and along main traffic routes we can find agricultural buildings (farmstead development) and the land used for crops and orchard cultivation.

The Świdnik area includes two forest complexes, i.e., the state-owned Rejkowizna Forest and the private Bażantarnia Forest. Furthermore, the vegetation cover of Świdnik contains cultivated green areas, i.e.: public parks, squares, leisure green spaces, allotment gardens, a cemetery, agricultural land, orchards, gardens, the grass surface of Lublin Airport, as well as the green areas situated next to: multi-family buildings, single-family buildings, farmsteads, commercial and industrial buildings, transportation infrastructure, and water supply and melioration facilities.

Basic analysis of ecotopes allowed to identify five ecotope types. Autonomous ecotope is located in the highest situated areas, in the south-west and north-east part of the analysed region. Autonomous-transitional ecotope is located in the highest parts of slopes. In Świdnik autonomous and autonomous-transitional ecotopes are mainly covered by forest which prevents intense erosion, i.e., the occurrence of eluviation or leaching. Transitional ecotope takes up the biggest part of the town. Urban development, industrial park and agricultural land are all located within this ecotope. Agricultural land (covered predominantly by pseudopodsols) is exposed to water and eolian (wind) erosion. Within the accumulative-transitional ecotope it can find a former landfill (at Krępiecka Street), and the accumulative ecotope (with optimal moist conditions, situated on the lowest ground) is rare – it can be found only in the Rejkowizna Forest and near Krępiecka Street (areas of farmstead development and agricultural land). It is agricultural land, the one most susceptible to anthropogenic pressure, which is especially prone to the accumulation of pollutants, e.g., heavy metals, chemical pesticides, nitrates used in land cultivation, oil derivatives (roads) or wastewater which, due to gravity, can penetrate to ground water and cause contamination of the Stawek river source.

Simplified analysis of ecotopes demonstrates that the most valuable land which makes it possible for the urban environment to function properly, is also the most endangered one. This concerns the accumulation of pollutants in accumulative and transitional-accumulative ecotopes, as well as the erosion processes taking place in transitional ecotopes.

Environmental structures analysis (Fig. 1) has shown that there is a number of ecological patches and islands within the town limits but there are no significant connections between them. Ecological patches are the state-owned (Rejkowizna) and private (Bażantarnia) woodland

areas as well as public parks, and the ecological islands include: Natura 2000 protected area, the remains of the Szpitalny Forest, the remains of the undeveloped dry valley, allotment gardens and the public cemetery.

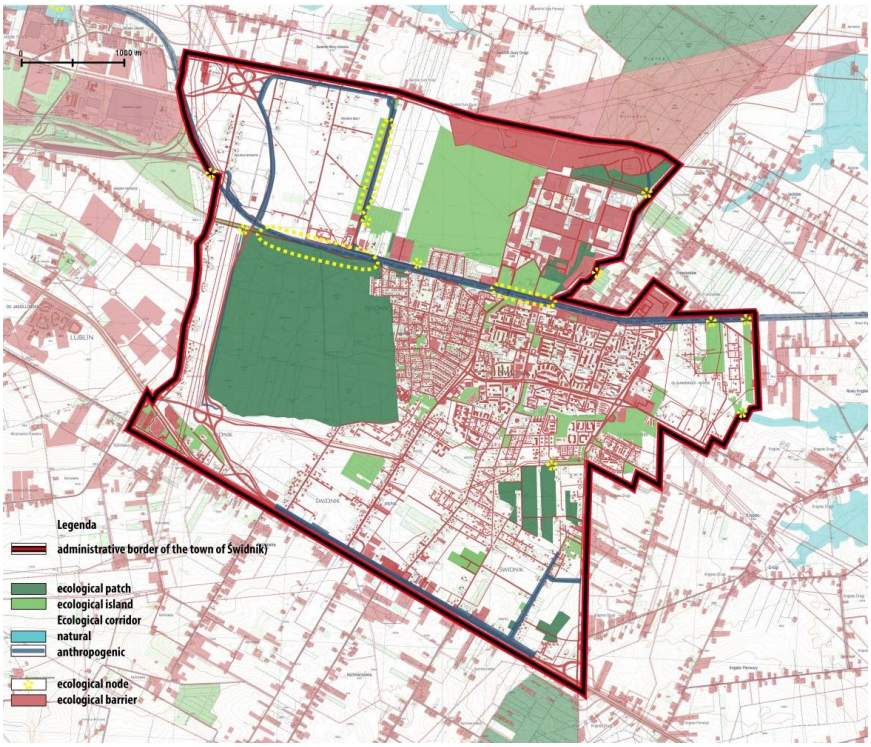

Fig. 1. Analysis of the environmental structures of Świdnik

Within the town limits there are no natural ecological corridors, however, there are a few anthropogenic corridors (drainage ditches along roads and railroad embankments). The latter structure in particular can function as a potential barrier for the distribution of plants between *different geobotanical regions* [33-37]. *In spite of the fact that they are disturbed habitats, they* create beneficial conditions for the development of rare, nectar source species, as well as invasive and potentially invasive species [38, 39].

The conducted analysis has also demonstrated that the construction of Lublin Airport created a huge barrier between the river valleys and forests – Szpitalny and Rejkowizna, which abruptly cut off any connectivity between them. It also pointed to a multitude of ecological barriers which inhibit free flow of animals in ecosystems: networks of roads, powerlines and areas of dense and scattered housing development.

Main threat for the quality of water in the Świdnik area are chemicals used in land cultivation and unsewered housing development [40]. Degradation of agricultural land causes soil exhaustion, and geological structure and landform features facilitate water and wind erosion. Urbanisation together with the intense development of technical infrastructure in the 21st century has led to a drastic reduction in biologically active surface. Air pollution in Świdnik is caused by industrial emissions, transportation emissions and area sources. Degradation of the town's flora is an outcome of continuous depletion of existing green areas (e.g. cutting down a part of the Szpitalny Forest for the construction of Lublin Airport [40], a part of the Rejkowizna Forest – for multi-family housing development, or a fragment of the Bażantarnia Forest – for single-family housing development), destroying the historic line of park greenery through development, or introducing alien (sometimes invasive) species into indigenous flora, which

has resulted in the decline of the local flora biodiversity. Threats to fauna stem primarily from human occupation of increasing portions of land and creating ecological barriers which make it difficult for animals to move.

The conducted analysis has shown that all threats, to a lesser or greater extent, influence the analysed natural components and each other (Table 1). Components particularly sensitive to urbanisation process and therefore the most endangered ones are flora and fauna; in their case all threats have current status.

Table 1. Current and potential threats to environment

	Threats	For water	For soil	For air	For fauna and flora
Local threats	Scattered development (single-family, farmstead)	C	–	C	C
	Industrial plants	–	–	C	C
	Excavations	–	–	–	C
Linear threats	National and regional roads	P	C	C	C
	District and local roads	C	C	C	C
	Railroads	–	–	–	C
	Power lines	–	–	–	C
Area threats	Agricultural land	C	C	–	C
	High-density development (town centre)	–	C	P	C
	Ownership fragmentation	C	C	–	C
	Industrial park	C	C	C	C
	Airport	P	C	C	C

Legend: [C] – current threats, [P] – potential threats, [-] – no threats

Analysis of trends in environmental changes (Fig. 2) has demonstrated that the main elements of environmental structure in Świdnik are two woodland complexes: Rejkowizna and Bażantarnia – ecological patches, as well as the dry river valley (an intersected ecological corridor). However, all these areas are exposed to strong anthropogenic pressure and their degradation is closely related to human management (investment pressure, deforestation). Reducing and intersecting the line of park greenery has made communication between the Rejkowizna Forest and Stawek river valley difficult. The woodland complexes constitute isolated spaces, deprived of the possibility of communication, and the housing development located nearby gives rise to the degradation of ecotone zones. Additionally, agricultural areas (monocultures) functioning as green fingers are being depleted to give place to new residential areas, consequently hindering communication between ecological islands.

Strategic areas for the desired development of the natural urban system include areas situated outside the town limits, i.e., Bystrzyca and Stawek river valleys, Szpitalny and Krępiecki forests, and – within its limits – Natura 2000 protected area, environmental use area, parks and the greenery of the oldest housing estates in Świdnik. According to B. Szulczewska [41], residential areas which are more than 50 years old, with a high percentage of biologically active areas (TBC), abundancy of trees, shrubs, lawns, and with a state ownership status, may be the key factor in creating man-made nature refuges, being at the same time a valuable element of the planned greenery system and natural urban system.

Analysis of the vegetation cover in all seven complexes of utilisation in Świdnik made it possible to distinguish 33 plant communities [Appendix A] representing nine phytosociological classes, 15 orders and 18 alliances. The acreage of particular phytocoenoses depend on the method and intensity of land use, and in particular on the structure of housing development. Undoubtedly, the biggest area is occupied by very unstable and transitory communities of synanthropic habitats (ruderal and segetal), characterised by spatial changeability.

Plant communities occurring in the forest-and-meadow complex consist mainly of meadow species as well as forest and shrub species (characterised by strong habitat attachment), and the agricultural complex are built of synanthropic taxons present on the periphery of arable

land, such as *Centauretalia cyani* and *Polygono-Chenopodietalia* order, which seldom appear in their usual form due to seed grain cleaning and chemical weed control. Multi-family and multi-family large-panel complexes are characterised by "extreme phytosociological poverty". Lawns and flower beds are populated by impoverished communities and various kinds of carpet communities. Plant communities in the industrial-transportation complex are largely ruderal phytocoenoses with lots of high perennial plants belonging to *Artemisietea vulgaris* and *Epilobietea angustifolii* classes, as well as carpet communities belonging to *Molinio-Arrhenatheretea* class. Vegetation cover of the garden and single-family detached complex consist primarily of patches of phytocoenoses belonging to *Molinio-Arrhenatheretea* and *Stellarietea mediae* classes, botanically impoverished and deprived of characteristic species. Physiognomy of this complex is shaped by nursery plants of high aesthetic value. Finally, the mixed complex (public parks, cemeteries etc.) is full of hard to define ruderal communities belonging to *Artemisietea vulgaris* or *Molinio-Arrhenatheretea* classes.

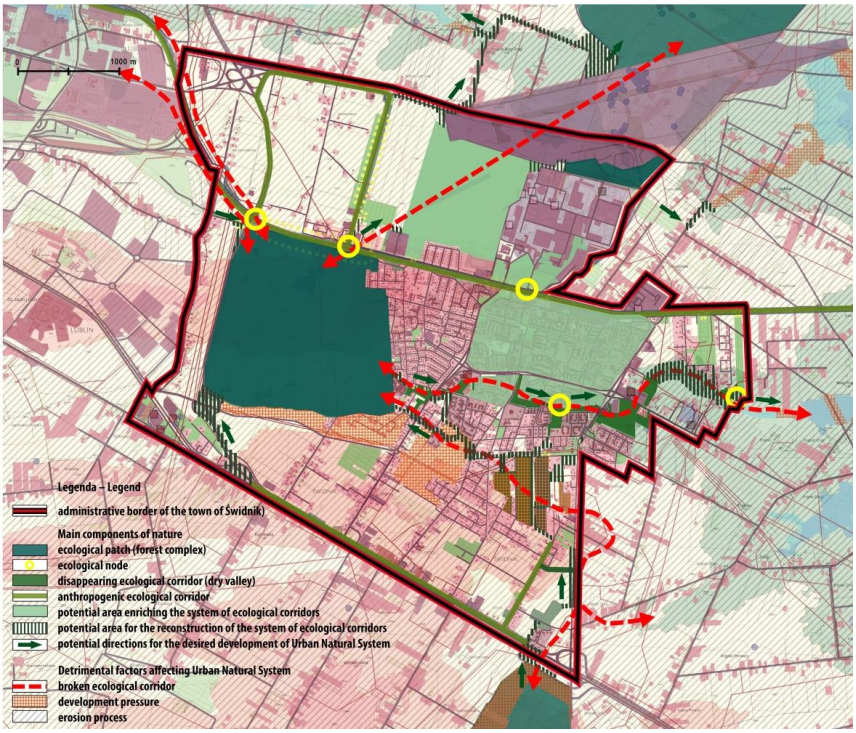

Fig. 2. Analysis of trends in environmental changes

The phytocoenoses designated in the complexes are formed by 350 species of plants [Appendix B] belonging to 63 botanical families, representing 219 genera. According *to J. Westermann et al.* [42] plant colonisation of a given area is determined by biological persistence, life form, type of life-history strategy, and the method of seed dispersal together with resilience to stress factors (degree of hemeroby). The research conducted in designated phytocoenoses has shown an evident dominance of indigenous species (65.3%), which is a very positive phenomenon when taking into consideration extreme environmental transformations and the possibility of the implementation of the research in planning strategies. Vegetation cover of Świdnik is dominated by perennial species (51.5%), hemicryptophytes (42.6%), which thanks to their morphology i.e., rosettes, buds at or near the soil surface, and long roots, can survive adverse habitat conditions caused by multidirectional human activity (e.g., new housing developments, frequent mowing, herbicides) [43, 44]. Study of the form of reproduction has

shown that the majority of plants reproduce by seeds and spores (57.0%), which is clearly visible in areas close to traffic routes. This relation supports M.J. Hansen and A.P. Clevenger's research [45] that linear structures (road shoulders, railway areas) favour spore mobility and wind dispersal, thus promoting the colonisation of new habitats [46]. Using this quality, the propagules of such plants are expected to disperse by themselves. The obtained results also confirm that the urban phytocoenoses are rich in entomophilous plants, mainly belonging to Asteraceae (15%), Rosaceae (9%), Brassicaceae (7%) and Fabaceae (7%) families which can increase food resources for pollinating insects by producing nectar and pollen [47, 48]. It also plays a significant role in installing "fashionable" insect houses, with decorative as well as educational values, in residential areas.

Species with highly competitive power prevail (37.8%) in the patches of phytocoenoses. They are especially perennial taxons, attractive for pollinators, reproducing by vegetative and generative reproduction, and the representatives of meadow and ruderal vegetation belonging to *Stellarietea mediae, Artemisietea* and *Molinio-Arrhenatheretea* classes. Most of them are urbanophilic species (with broad ecological spectrum) found in complexes with considerable anthropogenic pressure, whereas urbanophobic species can be found in the forest-meadow complex. Stress-resilient species, surviving extremely detrimental soil conditions (salinity, heavy metals), are very rare (1.4%). The results are consistent with botanical studies conducted in cities such as Poznań, Wiedeń and Warsaw [49, 50].

Absolute number of species in particular complexes depends not only on the acreage of a given phytocoenosis but also on its openness to an "influx" of alien components. In the multi-family large-panel complex, which can be described as a phytosociological poverty zone, the number of species is the lowest (67 species). The highest number of taxons can be found in the industrial-transportation complex (272 species). However, it should be noted that transportation areas are also the reservoirs of invasive species diaspores – a phenomenon confirmed by studies conducted in Poland and abroad [37, 51-56]. In Świdnik invasive species constitute 7.14% of all vegetation, those are: *Acer negundo, Amaranthus retrofeksus, Aster x salignus, Bunias orientalis, Conyza canadensis, Echinocystis lobata, Eragrostis minor, Erigeron annuus, Galinsoga ciliata, G. parviflora, Helianthus tuberorus, Impatiens parviflora, Juglans regia, Juncus tenuis, Oxalis fontana, Padus serotina, Parthenocissus inserta, Quersus rubra, Rhus typhina, Robinia pseudocacia, Rosa rugosa, Rumex confertus, Setaria pumila, S. viridis, Solidago gigantea*. A considerable fraction of this group are perennials, phanerophytes and hemicryptophytes, originally introduced into woodland area in order to obtain valuable wood resources or as a part of a phytomelioration scheme. Examples of such species include *Acer negundo*, *Padus serotina*, *Quersus rubra* and *Robinia pseudocacia*, observed predominantly in the industrial-transportation complex. The species introduced into gardens are *Echinocystis lobata*, *Helianthus tuberosus* and *Parthenocissus inserta*. Concentration areas of such species are consistent with the classic "invasion hot spot" concept [57].

Valuable and rare species of plants are scarce in the Świdnik area. In the analysed flora there are no species under either strict or partial protection [58]. A small group of rare alien elements consists of three species - *Amaranthus albus*, *Asperugo procumbens* and *Anagallis arvensis*. This is mostly due to the fact that the transformation of natural environment favours technical elements, i.e., roads – impenetrable surfaces, decorative greenery – alien/invasive vegetation. This kind of multidirectional human activity destroys natural habitats or makes them inaccessible. In urban environment there is a direct relation between negative processes (such as air, water and soil pollution, soil compaction, heat islands) and the composition of plant communities in terms of ecology. The most valuable areas are usually on the outskirts of the city or on parts of land under various forms of legal protection [4].

In case of the oldest Świdnik housing estates, the dry valley or public parks (recognized under the conducted ecophysiographic study as the areas with the best potential for the development of the Urban Natural System), it is recommended to replace impoverished communities with man-made nature refuges or natural type vegetation, i.e., flower meadows, green roofs, vertical walls etc. Species should be selected from secondary communities for a

given habitat, expressed as a type of potential natural vegetation. According to W. Matuszkiewicz [23], Świdnik constitutes a potential area of eutrophic deciduous forest, sub-continental oak-hornbeam forest (Małopolska variation, upland form, fertile series) - *Tilio-Carpinetum*, whose secondary communities are grassland, ruderal and segetal communities. Consequently, the standard for the development of vegetation forms should be oatgrass meadows - *Arrhenatheretum elatioris* rich in grasses and visually aesthetic herbs which are quite resistant to recreational use (Fig. 3), carpet communities with ryegrass and birdweed – *Lolio-Plantaginetum arenastrii* displays the highest index of the so-called natural absorbence in Polish conditions, and communities of high, flowering perennials with viper's bugloss and sweet clovers – *Echio-Meliloteum* in rich many decorative species, characterised by high biomass productivity which makes it fitting to be secondary vegetation for urbanised areas (Fig. 4) [59, 61]. This kind of reconstruction is the cheapest and the least interfering form of anthropogenic activity.

The taxons included in the above-mentioned communities are primarily indigenous species with unique abilities to grow and advance. Since their unquestionable benefit is resilience to droughts, they stand a greater chance to survive even the most extreme heatwaves without additional irrigation [60]. As early as in the 20th century *J. Janecki* [61], taking Warsaw as an example, pointed out that secondary communities are valuable in terms of their aesthetic, sensory and mental health properties, have low habitat requirements and may be essential for urban green areas. His list included: *Sisymbrietum loeselii*, *Artemisio-Tanacetum*, *Berteroetum incanae*, *Calamagrostietum epigei* and *Helianthetum tuberosi*, which were also inventoried in the Świdnik area. Their sites of occurrence are usually associated with the industrial-transportation complex and, in small percentage of cases, with the agricultural complex. This supports the idea that the role of ecological corridors may be taken over by anthropogenic systems (along traffic routes) which constitute reservoirs of biodiversity and using them to shape naturalistic vegetation has not only aesthetic but also ecological importance.

Fig. 3. *Arrhenatheretum elatioris* patch in a baulk strip in the north-west part of the town

Fig. 4. *Echio-Melilotetum* patch on a sandy-gravel intertrack space

Their unquestionable advantages are also resilience to anthropogenic impact on environment, natural range of distribution and wide selection, which prevents the creation of monocultures and gives an opportunity to prepare an individual design of urban greenery dedicated to a specific type of habitat. Interesting examples of how such species might be used are e.g., a Park High Line project from New York [62, 63], or the restitution of flood-meadows in the Warsaw part of the Natura 2000 protection area 'Middle Vistula Valley' [64]. Nevertheless, it should be pointed out that this innovative solution – using seed mix enriched in indigenous species – needs to be part of a long-term, consistently implemented scheme, since it involves considerable financial resources and long-term cooperation between local authorities and their partners (such as research centres or seed mix producers).

Conclusions

The presented application work concerns the town of Świdnik. The obtained results might be helpful for other towns of a similar size and at a comparable growth stage and can become guidelines for new rules of conservation and urban development. Urban landscape design should allow for a harmonious coexistence of all species, and not just the interests of one population which, by taking over common space only for its own benefit, becomes a threat for the remaining ones. The conclusions drawn from the study are as following:

1. Environmental structure analysis has revealed the lack of natural ecological corridors in the Świdnik area, which has an adverse effect on the town's biodiversity. Within the town limits (in the south-east and west part) there are two ecological patches, namely the Rejkowizna Forest and the Bażantarnia Forest. The two woodland complexes play an important role of supply areas, and as such should be given the status of protected areas.
2. Public purpose investments implemented at the beginning of the 21st century is gradually reducing Świdnik woodland area and breaking the communication of the ecological corridor. This leads to the obliteration of spatial connections between the town's greenery and suburban areas. As a result of this process the area of agricultural land with high soil quality class is getting smaller, thus reducing food-zones.
3. On the basis of the conducted ecophysiographic analysis it is recommended to rebuild the town's wedge-shaped natural system. The system should involve the following:
   a) reconstruction of the intersected ecological corridor – historic line of park greenery;
   b) introduction of the system of ecological patches encompassing protected areas (the environmental use area and the Natura 2000 area – due to scale and legal importance) as well as woodland areas;
   c) maintaining spatial connections between the environmental structures of neighbouring communes, i.e., river valleys – Bystrzyca and Stawek, forest complexes – Szpitalny and Krępiecki;
   d) introduction of vegetation cover (in accordance with habitat conditions) into areas with the biggest potential for the development of the Urban Natural System, e.g., reconstruction of the intersected ecological corridor;
   e) continuous monitoring and, if possible, reducing current and potential sources of threats which lead to environmental components degradation.
4. The greatest botanical and phytosociological diversity was identified in the industrial-transportation complex which functions as an anthropogenic corridor and for that reason it should be used to develop naturalistic vegetation.
5. Botanical research conducted in the Świdnik area has shown that the standard for the development of vegetation forms in urban areas should be oatgrass meadows (*Arrhenatheretum elatioris*), carpet associations with ryegrass and birdweed (*Lolio-Plantaginetum arenastrii*) belonging to *Molinio-Arrhenatheretea* class, as well as communities of high, flowering perennials with viper's bugloss and sweet clovers (*Echio-Melilotеum)* belonging to *Artemisietea vulgaris* class. The taxons included in the above-mentioned communities are primarily indigenous species with unique abilities to grow and advance, colourful inflorescence – blooming profusely or for a long time (visual effect) and producing nectar and pollen (food resources for pollinating insects). Since their unquestionable advantage is resilience to droughts, they stand a greater chance to survive even the most extreme heatwaves without additional irrigation, as well as soil salinity and pollution (urbanophilic species).
6. Professional vegetation composition (Appendix B) for green areas, in line with biocoenotic and biotopic conditions, should be included in planning documents. Only this way will we be able to protect the assets and functions of ecosystems, keep their optimal biodiversity levels, and bring numerous benefits not only to people but also to the flora and fauna of the studied area.

7. It is necessary to monitor plant cover in order to eliminate invasive and potentially invasive species and to keep current records essential for the formulation of planning documents.

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