

## MAINTANING NATURAL CONNECTIVITY OF NATIONAL AND REGIONAL IMPORTANCE IN TERMS OF LOCAL LAND-USE PLANNING AND MANAGEMENT – THE CASE STUDY OF WIELISZEW MUNICIPALITY

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### ABSTRACT

The article concerns the maintenance of ecological connectivity of regional importance, as illustrated with the example of the Wieliszew municipality in the vicinity of Warsaw. The study consisted in analysing the landscape structure of the municipality, determining the existing natural connections and assessing their spatial continuity and functioning. The developed ecological network was confronted with the planned functional and spatial structure according to the study of spatial development conditions and directions, in particular in terms of the spread of anthropogenic barriers. The planned dense built development and new road of regional importance lead to significant fragmentation of the landscape, and thus result in limitation and the decrease in efficiency of the existing ecological connections.

**Keywords:** ecological network, ecological corridors, spatial planning, land development

### INTRODUCTION

One of the priority issues of contemporary environmental protection is the protection of biodiversity, which requires the dispersion, migration and free exchange of genes of many species between habitat areas. The main reasons for their isolation include the increasing fragmentation of landscape as a result of growing anthropogenic pressure, the decline of the biologically active areas, and the simplification of the natural structure. The rate of biodiversity reduction depends mainly on the degree of natural condition and the size of ecosystems. The process occurs more slowly in natural and extensive areas, held back by internal self-regulation processes, whereas negative changes occur initially mainly in the ecotone zone (transition area). Faster loss of biodiversity takes

place in ecosystems that have already been partially transformed as their area decreases (Chmielewski and Chmielewski, 2015).

The classic approach to nature conservation, consisting in giving special status to selected areas or species protection by isolating them from human activity, had proven ineffective (Bennett and Wit, 2001; Worboys et al., 2010). Currently, it is recognized that the prerequisite for effective nature conservation is the preservation of ecological communication between nodal areas – natural or semi-natural, characterized by a high degree of biodiversity, suitable size, with varying degrees of significance (from continental to local). Connectivity is provided by ecological corridors – structural elements of the environment, of various types, shapes and sizes (natural, semi-natural and anthropogenic, linear, banded or area, spatially continu-

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ous and non-continuous). Around the above-mentioned elements forming the so-called ecological network, it is preferable to designate buffer zones, eliminating or reducing external threats, in which extensive and sustainable activity is allowed (Chmielewski, 2009; Pchalek, 2011; Bernatek and Jakiel, 2014).

The ecological network has a hierarchical structure. The implementation of generally formulated goals related to maintaining natural connectivity of national and regional importance requires detailed specification in relation to local development conditions and priorities. Balancing developmental factors of a social, economic, cultural and natural character in the system of supra-local and local connections is the basic task of spatial management in the municipality.

Maintaining natural communication is a difficult task, among others due to insufficient legal support for the implementation of the ecological network in the Polish spatial planning system (Szulczewska, 2004; Żarska, 2006; Pchalek et al., 2011; Brzank and Pawlat-Zawrzykraj, 2013; Bernatek and Jakiel, 2014; Sobieraj and Zacharczuk, 2016). The scope of activities includes, *inter alia*, defining restrictions in the management and use of ecological corridors, indicating places and ways to pass through the existing ecological barriers, and avoiding the creation of new barriers (Rozenau-Rybowicz and Baranowska-Janota, 2007). Such goals should be formulated in the study of conditions and directions of the spatial development of the municipality, and then specified in the local spatial development plans. Quoting from Żarska (2006), “local level from the point of view of species migration is the level (...) determining the ‘to be or not to be’ of individuals in the population, defined, among others, by the possibility of a forest-inhabiting species passing to the neighbouring forest complex, or the lack of that possibility. In such a local perspective, communication in the region is less of a priority, since the individual can not pass to the nearest neighbouring refuge.”

The aim of the present work is to analyse and evaluate the local spatial policy of the Wieliszew municipality in the context of maintaining ecological connectivity of regional importance. The location of the Wieliszew municipality within the scope of the social and economic impact of Warsaw and the associated projected demographic growth means that it

increasingly links its development with a residential and service function. The current spatial policy of the municipality is planning to significantly increase the share of areas with these functions, which will inevitably affect the functioning of the natural environment in the local dimension, but it can also contribute to trans-local changes. The results of the assessment can be the basis for verification of the principles of shaping the landscape, and the directions of spatial development of the local spatial unit under consideration.

## STUDY AREA

The studied object is the rural municipality of Wieliszew (in the Legionowo district) located approximately 30 km north of the centre of Warsaw. The municipality has an area of 10 609 hectares. The structure of land use is dominated by arable lands (54.2%), forest and woodlands occupy 28.3% (forest cover is 26.6%), built-up and urbanized lands are 9.5%, and land under waters is 5.5% (BDL, status as per 2014). The general assessment of the functional and spatial structure of the municipality indicates its diversity in terms of functions and levels of urbanization. In the northern and central part, parallel to the Narew River valley, there are mostly natural or slightly transformed areas, that is, forest areas and extensively used agricultural land of meadows and wetlands. Residential and recreational developments in the northern part of the municipality are concentrated within a few small areas (Sikory, Topolina, Podębie). The regional-grade road DW 631 is the axis of the municipality’s economic development, leading, among others, to the Zegrze Reservoir in the neighbouring Nieporęt municipality and towards Warsaw via the S7 road. Currently, along the DW 631 road there are small areas used for agriculture, service and housing development, partly along the road, and partly dispersed, but rarely concentrated (Wieliszew, Kałuszyn, Olszewnica, Janówek). In the southern part of the municipality, two large forest complexes are located: Uroczysko Poniatów and a fragment of Chotomów forests.

The municipality has a significant position in the structure of national and regional environmental links (KPZK, 2011). According to the project of ecologi-

cal corridors linking the European *Natura 2000* network in Poland, a significant part of the Wieliszew municipality belongs to the Lower Bug river corridor (marked GKPNc-4), creating direct (through the Narrow valley) and indirect (North-South) connections with the Central Wisła Valley corridor (GKPPnC-10A) – see: Figure 1. In the Spatial Development Plan of the Mazowsze Region (PZPWM, 2014) the analysed municipality is located in the area constituting the Green Ring of Warsaw, composed of the largest areas of nature protection in this region (Kampinos National Park, Mazowsze Landscape Park and Chojnów Landscape Park and the Warsaw Area of Protected Landscape – WOCHK). A significant part of the municipality (62%) lies within the limits of the WOCHK. The remaining, small protected areas include the special habitat protection area (SOOS) of Forty Modlińskie (code PLH 140020) in the south-western part of the municipality, and the Wieliszewskie Łęgi nature reserve in the north-eastern part. The location of the municipality within the range of Warsaw’s suburbanization also sets the priorities for regional infrastructure connections, including, above all, the so-called “Small Ring Road of Warsaw”, part of which is the provincial road DW 631 Marki–Nieporęt, and the national road

DK 61 Zegrze Południowe–Legionowo–Jabłonna, located in the analysed area.

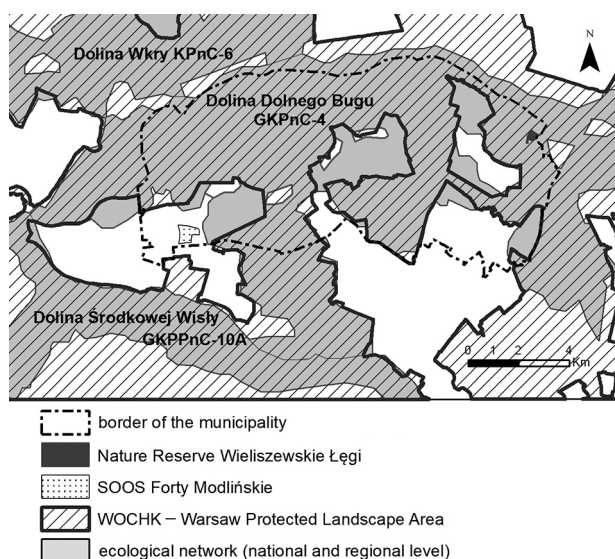
The municipality had the population of 13,151 inhabitants, according to data from 2016. In comparison to data for 2010 (11,306 inhabitants), an increase of 16% was noted. The projections for the Legionowo district until the year 2035 (USWAW, 2011) assume an increase in the number of population in relation to the actual data of 2010 by 28.9%. Population density was 107 inhabitants per 1 km<sup>2</sup> in 2010, and 124 inhabitants per 1 km<sup>2</sup> in 2016 (average for Legionowo district is 293 people per 1 km<sup>2</sup>, according to BDL).

According to the physical and geographical regionalization developed by J. Kondracki (1994), the municipality is located in the Central Mazovian Lowland, in the mesoregion of the Warsaw Basin, on the border with the Ciechanowska Upland.

## RESEARCH METHODOLOGY

As the basis for the formulation of directions and principles for shaping the natural landscape of the municipality in the aspect of counteracting its fragmentation, the elaboration of its ecological structure was adopted using an *a priori* approach, based on the assessment of landscape elements in terms of their usefulness for organism migration (Solon, 2009). The approach used in the literature is also called *structural* – connections between nodal areas are created using the pre-existing structures in the landscape, assuming that these may be useful for the preservation of natural communication (Szulczewska, 2004). Due to the considerable detail of spatial analysis, the Żarska (2006) methodology was used, based on the ecological model of municipalities and the ecological truss concept. Spatial and landscape units were designated on the basis of land coverage and land use as well the terrain and landforms. The database of topographic objects BDOT10k was applied, having been made available by the Centre for Geodetic and Cartographic Documentation, as well as orthophotomaps and topographic maps obtained from the WMS Geoportal service. Spatial data was updated during field studies carried out in the autumn of 2017.

Within the area of the Wieliszew municipality, the following spatial and landscape units have been defined: woodland in the flood terraces of the Narew



**Fig. 1.** Location of the Wieliszew municipality within the ecological corridors of the European Ecological Network *Natura 2000* (after Jędrzejewski, 2011) and nature conservation areas.

River (marshy, alder, osier, willow-alder-birch), forests above the terraces and in dune elevations (fresh coniferous forest, mixed forests with a small share of mixed and mixed coniferous forests), floodplain meadows (wet meadows with a small share of natural bog communities and rushes), surface waters (flowing and standing), arable land with the participation of mid-field trees, and built-up areas. The built-up areas have been classified as barriers limiting the movement of fauna, especially in the case of settlement units with an extended, linear structure, and particularly those located along roads with heavy traffic. The number of vehicles per day (see: Table 1) was assumed as the basis for the assessment of the “barrier effect” of existing roads, after Müller and Berhound (1997).

**Table 1.** The level of risk to fauna as a function of the increase of traffic (after Müller and Berhound, 1997)

No of vehicles per day	Intensity of traffic	The level of risk to fauna
< 1000 vehicles/day	Low traffic intensity	Low risk to migrating fauna
1000–10 000 vehicles/day	Average traffic intensity	Average risk, mostly in the road lane, the barrier partially passable
> 10 000 vehicles/day	High traffic intensity	High risk to fauna, with spatial range of the double road lane, which poses a non-passable barrier (many animals migrate along the road instead), an overpass or underpass is required.

The data from the General Traffic Monitoring (GDDKIA, 2016) was used to assess the level of traffic on the main supra-local roads in the Wieliszew municipality and in its immediate vicinity (GP class – the main road of accelerated traffic, G class – the main road, and Z class – the collector road)

In order to determine nodal areas and to illustrate the rank and the course of ecological corridors, in accordance with the methodology proposed by Źarska (2006), an ecological and spatial model of the land-

scape and a model of external connections were developed. The concept of ecological network was confronted with natural connections determined in the current study of conditions and directions of the spatial development of the Wieliszew municipality (Resolution No. XXXVII / 373/2013).

Then, in the areas of existing or potential ecological corridors, the following were analysed:

- directions of the municipality’s development in the scope of the planned spread of developed built up areas and the expansion (or reconstruction) of communication barriers of a supra-local rank (Resolution No. XXXVII / 373/2013, GDDKIA, 2011)
- coverage with local spatial development plans, and arrangements contained therein affecting the maintenance of environmental and ecological connectivity, in particular those elements of regional importance.

The results of the above analyses provided the foundation for indicating the areas that require additional interventions (hot spots) in order to strengthen or maintain their existing function in the designated network of natural connections.

The maps were developed using the ArcMap 10.4.1 application of the ArcGIS software package.

## RESULTS

The analysis of the spatial and landscape units determined on the basis of the terrain and landscape designation indicates the existence of 5 large forest patches. Three of these have a peripheral location: Uroczyso Poniatów (area of about 630 hectares) and a fragment of Chotomów Forests (area of about 315 hectares within the boundaries of the Wieliszew municipality, out of over 1500 hectares of the total area) at the southern border with the Jabłonna municipality, and in the east, an area adjacent to Nieporęt Forests (the area of about 170 hectares out of the total 1150 hectares). They are characterized by a compact structure, moderately extensive peripheral zone, and they are surrounded with a mosaic of agricultural areas, acting as buffer zones. They constitute habitats for many species of mammals such as: foxes, wild boars, martens, polecats, elks, deer, hares and roebuck. The currently small built-up areas (mainly dispersed) and provincial

road DW 631 do not limit the movement of species towards smaller forest shelters located in the central and northern part of the municipality. Stronger isolation of forest shelters is visible on the side of the concentrated development of the city of Legionowo, and the DW 630 road that is parallel to the Wisła River valley. The remaining two larger forest areas are located in the central and northern part of the municipality. These are mainly coniferous forest habitats with a small share of mixed forests in the areas of a slightly elevated terrace. An important factor is their spatial connection with a large number of small forest areas, often surrounded with meadow and meadow-marshland areas, which can act as intermediate shelters. The remaining forest units are willow-poplar forests in the Narew River valley and the floodplain terrace (the largest ones in the vicinity of Kępa Kikolska and north of the village of Wieliszew).

The location of the Wieliszew municipality within a wide valley, and especially the extensive floodplain terrace made of river sands with mulches, humus sandy silts and organic deposits, peat bogs and peat mire supports the maintenance of meadow areas. The largest areas of this type are the Krubińskie Meadows and the Wieliszewskie Meadows. In the first case, this is a vast complex of partially drained meadows, with additional natural values of small depressions permanently or periodically filled with water, the Klucz Lake and Góra Lake, and numerous mid-field trees, providing shelters. Residential and recreational facilities were developed along the Klucz Lake and the village of Sikory. The spreading of buildings in this area is primarily limited by difficult geotechnical conditions. For animals, the area can be both the habitat and a stop-over in migration between the valley and the forest refuge in the southern part of the municipality. The Wieliszewskie Meadows (in the north-eastern part of the municipality) are located in the immediate vicinity of alluvial forest complexes, some of which are covered by protection as nature's reserves (Łęgi Wieliszewskie Reserve).

Spatial and landscape units with the dominance of agricultural land are located within the terrace above the floodplain, mainly in the central part of the municipality, on the east-west axis, and between the forest shelters in the southern part of the municipality. In these areas, small complexes of tree shelters and

shrubs have been preserved. An unfavourable tendency towards the emergence of dispersed residential development is visible, potentially limiting the possibility of free migration.

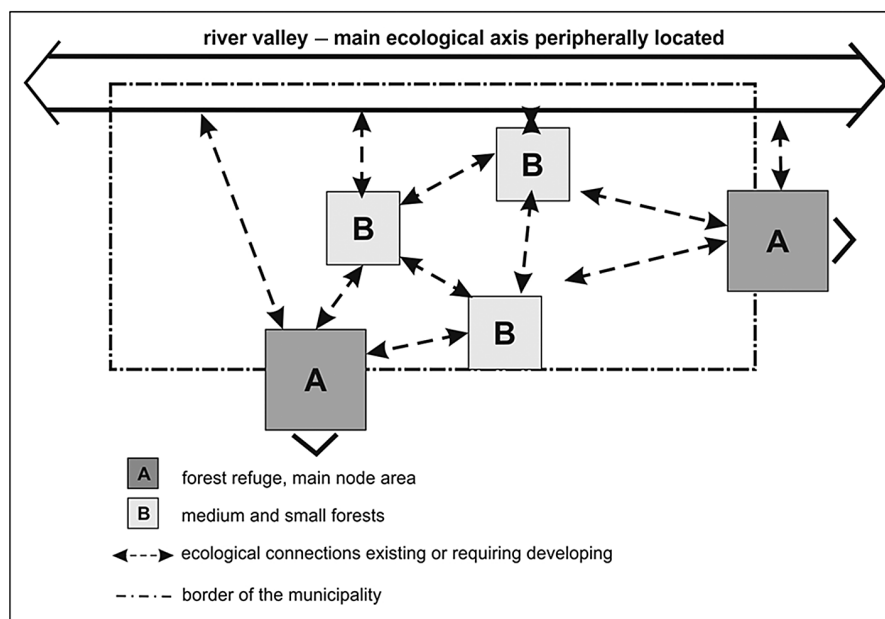
Settlement units in the Wieliszew municipality are primarily residential, with mixed residential and service function, and recreation areas with low intensity. Several places of settlement concentration are located along the DW 631 road, which currently does not constitute a barrier that would prevent the movement between the shelters in the northern and southern parts of the municipality.

Analyses of the structure and distribution of designated spatial and landscape units indicate a clear system of natural connections, the main element of which is the Narew River valley and forest refuge. According to the methodology developed by Żarska (2006), for the purpose of further indications informing the shaping of the ecological network in the studied municipality, the ecological and spatial model of the landscape has been defined. The municipality represents a fairly frequent, complex model, of axial-mosaic type, rich valley-forest subtype (see: Fig. 2). In this case, one of the basic recommendations is to maintain (support and reinforce) or to restore ecological connectivity transversely to the main ecological axis, and to maintain or create internal links, as well as external radial links from the main shelters.

Valley corridors and forest corridors (forest and meadow) have been designated – see: Figure 3. The basic valley corridor (of grade I) is the valley of the Narew River. The corridor along the Bródnowski Canal was considered a linkage of low rank (grade III) due to its strong anthropogenic impact.

The most important forest corridors (of grade II) are those constituting the connection between the valley of the Narew River:

- Krubińskie Meadows – forest refuge of Chotomowskie Forests – Wisła River valley,
  - forest refuge of Poddąbie – forests of Nieporęt.
- Forest corridors of the third grade:
- forest refuge to the west of Topolina – Klucz lake – Krubińskie Meadows,
  - forest refuge of Olszewnica – forest refuge of Uroczysko Poniatów,
  - Wieliszewskie Meadows – forest refuge of the Nieporęt Forest.



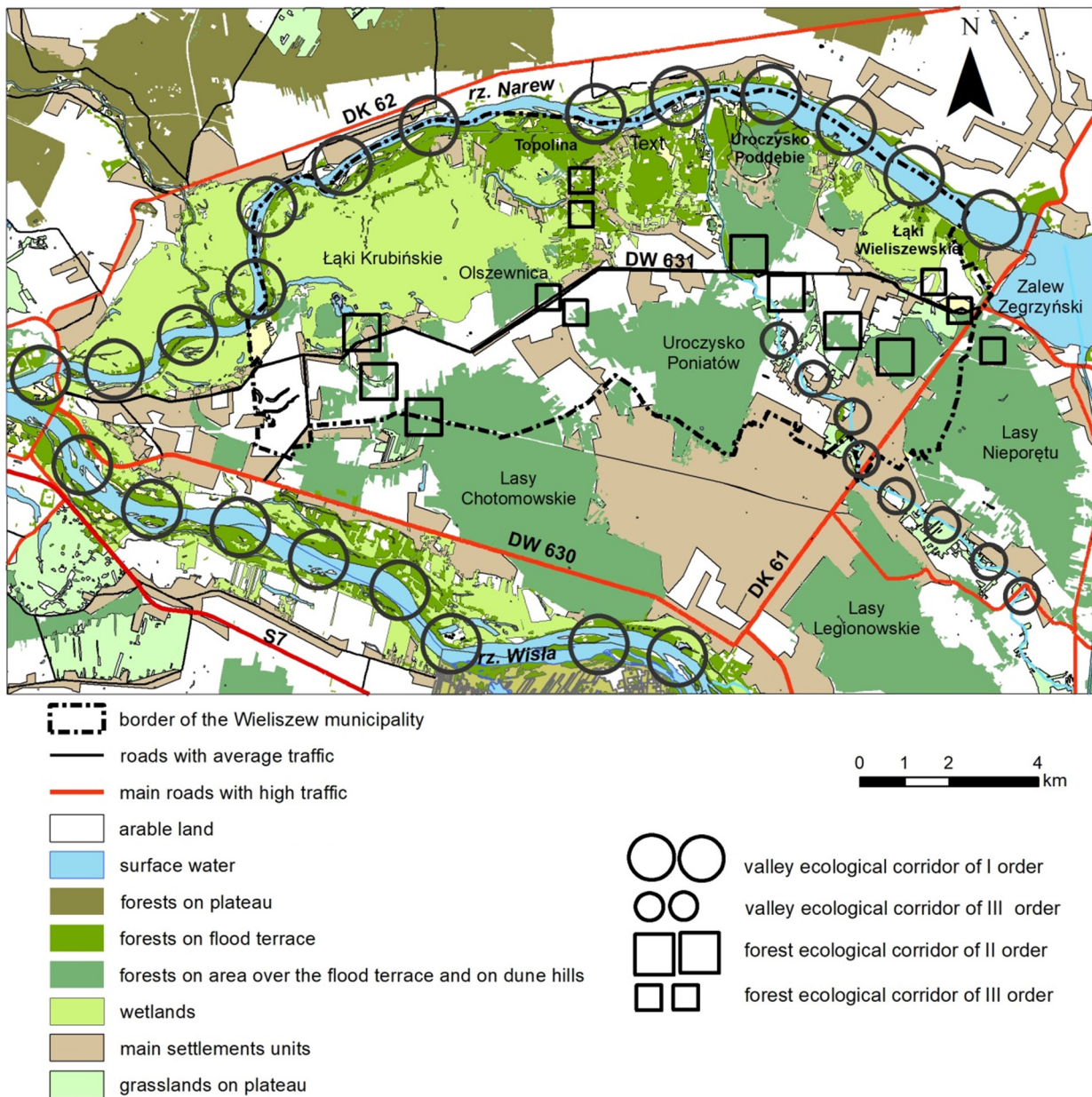
**Fig 2.** Ecological-spatial model of the Wieliszew municipality landscape

Source: own study

The forest corridor towards Wisła River through the Chotomowskie Forests is a priority from the point of view of regional connections. The current state of development between the meadow and forest refuges enables the migration of large and small mammals (through the Krubińskie Meadows, which is the grey heron colony and the place of occurrence of many other birds – as well as small forest complexes of intermittent nature and open agricultural spaces). The corridor is crossed by the DW 631 road, along which the development of residential and service buildings with a continuous band structure is planned. To the south, parallel to DW 631, a new road is planned of the so-called “Olszynka Grochowska” (of GP class). The planned development of buildings and road infrastructure along the section of about 2 kilometres narrows the corridor to a width of 200–300 m between the buildings in the villages of Janówek Pierwszy and Krubin, which according to the literature of the subject (Adamski et al., 2004; Perzanowska et al., 2005) should allow the movement of amphibians and small mammals. For a part of this area, local spatial development plan establishing the boundaries of built development was adopted. In the case of

a new road, it will be necessary to construct overpasses for medium and large sized animals (hotspot No. 1 – see: Fig. 4).

Second-grade forest corridor towards the forest of Nieporęt on the section between two forest refuges (south of the village of Wieliszew) has an intermittent nature with patches from 100 to 400 m wide. It consists of small forest complexes surrounded with agricultural land. The existing buildings and the road transport system do not pose significant spatial barriers. In the eco-physiographic analysis developed for the current study of conditions and directions of the spatial development (Skorupski and Laszczka, 2011), the need to strengthen the functioning of this corridor is emphasized, which is not reflected in the planned functional and spatial structure of this part of the municipality. In accordance with the current development directions, an area of concentrated built development is planned here, mainly residential one-family and multi-family housing. Existing local plans do not include the key section of the corridor. In this situation, it is necessary to clarify the development principles with the view to protecting natural connectivity, first of all designating areas for afforestation, maintenance of unprotected open ar-

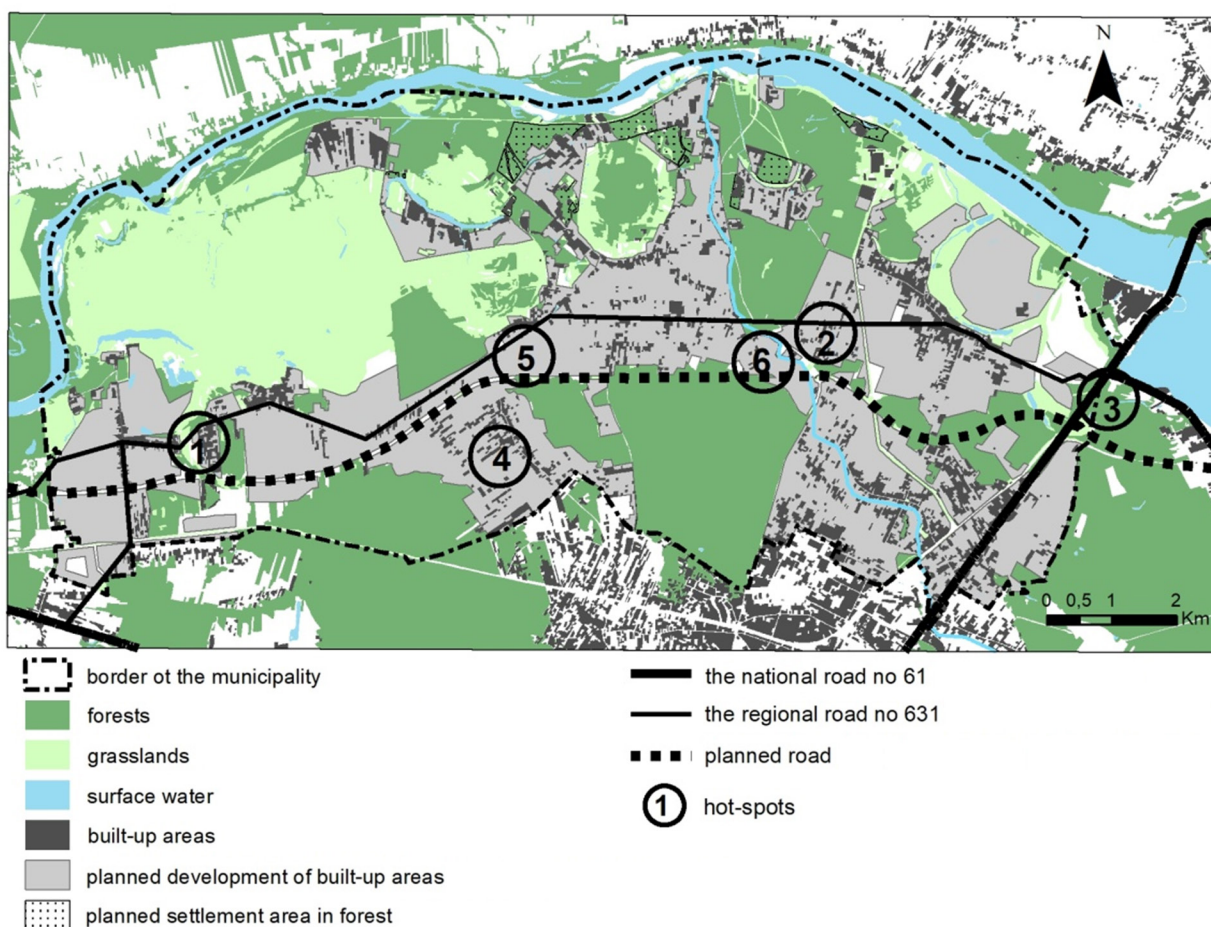


**Fig. 3.** Ecological structure and ecological corridors of Wieliszew municipality (own study)

Source: own study

eas, open passages and lanes between buildings with a minimum width of 50–100 m (Perzanowska, 2005) (hotspot No. 2 – see: Fig. 4). An important spatial barrier of this corridor is the DK61 road, which handles transit traffic in the Legionowo – Zegrze Południowe section (western border of the municipality). The mod-

ernization of DK61 to bring it up to GP class parameters is planned. The average daily traffic on this section of the road in 2015 amounted to 16,013 vehicles per day (GDDKiA, 2016), which indicates the level of the existing threat. In the case of road modernization, the traffic forecast for 2030 will be 28,830 vehicles per



**Fig 4.** Main directions of spatial development of the Wieliszew municipality, which may pose a potential risk to the maintenance of the regional ecological connectivity

day (GDDKiA, 2011). Due to the high risk for animals moving through the Nieporęt forests towards the valley on the section between 2 + 000 and 4 + 000, underpasses are planned for medium sized and large animals (hotspot No. 3 – see: Fig. 4).

The analysis of development directions included in the current study indicates the lack of actions to maintain the natural communication between the forest refuges of the Uroczysko Poniatów and Lasy Chotomowskie (hotspot No. 4 – see: Fig. 4). The study assumes a significant expansion of single-family housing as a continuation of this type of function in the neighbouring Legionowo. The situation is similar in the case of the third-grade corridor between Uroczysko Poniatów and the forest complex near Olszewnica

(hotspot No. 5 – see: Fig. 4), where the planned band development of buildings along the DW631 road will significantly reduce the natural connectivity between these sites. The target spatial layout of the buildings around the Poniatów forest complex leads to its natural isolation. In this case, the corridor along the Bródnowski Canal (grade III), which may allow the migration of some species (small mammals, amphibians) towards the north and south-west (hot spot No. 6 – Figure 4), is of significance.

The analysis of the planned changes in the spatial development of the municipality for the areas of other local ecological corridors indicates the possibility of maintaining their importance for natural communication.



## CONCLUSIONS

1. The land use structure of the Wieliszew municipality indicates a significant share of natural and semi-natural ecosystems. In the ecological structure of the municipality, the following are distinguished: the Narew River valley, vast meadows of the floodplain terrace, a few medium-sized forest complexes on dune elevations surrounded by areas of draining meadows in the central part of the municipality, and three large forest complexes of the peripheral terrace over the floodplain, along the southern and south-eastern border of the municipality.
2. The existing natural and landscape units create their external links between them: of valley and forest (forest and meadow) character. The valley of the Narew River has the highest rank, creating a corridor of supra-regional importance. The main forest refuges constitute the element of regional connections, linking, among others, ecological corridors of the Narew River and the Wisła River.
3. The current extensive development of the areas surrounding the main forest refuges allows for maintaining ecological communication between them, mainly of an intermittent nature, and rarely continuous.
4. The existing spatial policy of the municipality assumes further development of built-up areas (mainly residential and residential-service functions), primarily along the DW 631 road crossing the main forest corridors. The effect of the spatial barrier will be strengthened if the planned new road of Olszynka Grochowska is constructed. Areas of compact development are also planned around forest shelters in the central and eastern parts of the municipality.
5. The implementation of the adopted development directions will contribute to a significant fragmentation of the landscape and the natural isolation of the main forest refuges in the southern part of the municipality. Consequently, it will negatively affect the natural connectivity of regional importance.
6. It is necessary to verify the spatial policy of the municipality, with the view to the preservation, protection and shaping of intermediate sites on the ecological corridors route between the main refuges, and the “friendly” development of land around the most valuable natural areas.

7. The main directions of activities in the municipality’s spatial policy for sensitive places within the networks (the hotspots) should consist in limiting the development, in promoting afforestation, construction of crossings and overpasses for animal crossings, and indicating these areas as priorities when drawing up local spatial development plans.

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## UTRZYMANIE ŁĄCZNOŚCI PRZYRODNICZEJ RANGI KRAJOWEJ I REGIONALNEJ, A POLITYKA PRZESTRZENNA GMINY – NA PRZYKŁADZIE GMINY WIELISZEW

### ABSTRAKT

Artykuł dotyczy utrzymania powiązań przyrodniczych rangi regionalnej na przykładzie podwarszawskiej gminy Wieliszew. W pracy przeanalizowano strukturę krajobrazu gminy, wyznaczono istniejące powiązania przyrodnicze, oceniono ich przestrzenną ciągłość oraz funkcjonowanie. Opracowaną sieć ekologiczną skonfrontowano z planowaną w studium uwarunkowań i kierunków zagospodarowania przestrzennego strukturą funkcjonalno-przestrzenną – w szczególności w zakresie rozprzestrzeniania się antropogenicznych barier. Planowany rozwój zwartej zabudowy oraz nowe drogi rangi ponadlokalnej wskazują na możliwe znaczące ograniczenie funkcjonowania korytarzy ekologicznych rangi ponadlokalnej w wyniku fragmentacji krajobrazu.

**Słowa kluczowe:** sieć ekologiczna, korytarze ekologiczne, planowanie przestrzenne, zagospodarowanie przestrzenne