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**DIVERSITY OF THE INFLUENCE OF URBANISATION ON
VALUABLE NATURE AREAS ACCORDING TO SELECTED
FEATURES OF THE CITIES OF WIELKOPOLSKA**

key words: city location, protected area, conflict, Wielkopolska

INTRODUCTION

Urbanisation is considered to be one of the main causes of the fragmentation of the natural environment (Kozłowski, 2002; Hough, 2004; Benedict, McMahon, 2002), which constitutes a serious danger to biodiversity (Colinge, 1996; Beatley, 2004) and has an adverse effect on the abiotic environment (Zimny, 2005). The expansion of investment at the expense of open areas results in their fragmentation and isolation, which hinders the movement of living organisms and restricts gene exchange (Ahern, 1995), and in consequence leads to impoverishing the diversity of habitats and interference into or destruction of their natural functions (Andrzejewski, 1986).

In order to mitigate the adverse effect of urbanisation on the natural environment, and in particular to protect biodiversity, it is essential to preserve the spatial continuity of open areas. Because of the location and intensity of investment cities¹ contribute to a various extent to the fragmentation of areas performing natural functions of regional and extra-regional significance. Therefore the purpose set for this study was to diagnose the spatial relations between cities and valuable nature areas, which resulted in the determination of the following:

- surface area and share of valuable nature areas surrounding cities,
- pressure exerted on valuable nature areas based on selected features,

¹In this paper *city* shall mean either *city* or *town*.

- typology of the cities of the voivodeship of Wielkopolska according to the varied value of the natural environment in their surroundings and pressure exerted on the natural environment,
- instances of spatial interference of cities with valuable nature areas.

METHODOLOGY

The analysis performed involved the administrative boundaries of 109 cities of the voivodeship of Wielkopolska including a 1 km wide belt surrounding them. The choice of the area based on the administrative division was motivated by the fact that it is according to this division that planning documents – such as studies on conditions and directions concerning communes, and local spatial management plans – are created and spatial management related decisions are made.

To characterise quantitatively the location of cities according to the assets of the natural environment, the analysis encompassed an extra 1 kilometre wide zone along the administrative boundaries of the cities. The analysis involved establishing the surface area of valuable nature areas (partly determined by the city surface area) and their share in the analysed zone (determining the possibility to link the regional nature system with its areas within cities). Such an approach permitted to diagnose the location of cities in relation to the natural assets of their surroundings without referring to valuable nature areas inside cities, being only a small part a greater nature system.

The 1 km width of the surrounding belt was selected as a result of an analysis of 2-km and 5-km alternatives, which showed a statistically significant correlation of over 0.9 for 1 and 2-km wide zones and over 0.7 for 2 and 5 km wide zones. The analysis aimed to select the zone, in which the nature system should be analysed. The results show that the 1 km wide zone is representative of wider city surroundings.

The following were considered as valuable nature areas: national parks, landscape parks and reserves, CORINE biotopes areas (subsites), ECONET areas and wildlife corridors connecting the NATURA 2000 network.

The analysis was performed using the data standardisation method according to the following formula:

$$z_i = (x - u) / q$$

where:

z_i - standardised size of the analysed areas or features in city i ,

x - standardised variable,

u - average for the set,

q - standard deviation of the set.

As a result the average value obtained for all variables for the cities of Wielkopolska was zero, values above the average were positive, and values below the average were negative. This permits to compare quantitative characteristics of cities expressed in different units.

In order to diagnose the natural surroundings of cities, the following synthetic index of natural environment value was developed:

$$WWSP_i = zpoe + zuoe + zpoc + zuoc + zpke + zuke + zpfop + zufop$$

where:

- WWSP – natural environment value index of city i ,
- zpoe – standardised surface area of ECONET areas,
- zuoe – standardised share of ECONET areas,
- zpoc – standardised surface area of CORINE biotopes areas (*subsites*),
- zuoc – standardised share of CORINE biotopes areas,
- zpke – standardised surface area of corridors linking NATURA 2000 areas,
- zuke – standardised share of corridors linking NATURA 2000 areas,
- zpfop – standardised surface area of selected natural environment protection forms,
- zufop – standardised share of selected natural environment protection forms.

In order to characterise the urban pressure the following city features were selected based on relevant literature: the surface area of areas used for investment, the density of hard-surface roads, land use changes from open areas to investment areas between 1990 and 2000 and the population density in areas with urban fabric. Investment areas include industrial, commercial and transport areas, continuous and discontinuous urban fabric, mine, dump and construction sites (EEA, 2007). The choice of those areas was motivated by the fact that road infrastructure along with expanding urban development are the main causes of the fragmentation of natural environment (Makomska-Juchiewicz, 2007; Geneletti, 2004; Breuste, 2004). Population density in turn translates into development intensity, and according to Alberti and Marzluff (2004) multi-family housing plots have a considerably larger share of tight areas than single-family housing plots. Based on this it was established that higher values of each of the adopted features evidence a stronger urban pressure on valuable nature areas.

Based on the values of city features standardised according to formula z_i the following urban pressure index was defined:

$$WPM_i = zp_z + zg_{sd} + zg_z + zp_{zpt}$$

where:

WPM_i – urban pressure index of city,
zpz- standardised surface area of areas used for investment,
zgśd – standardised density of road network,
zgz – standardised population density in areas with urban fabric,
zpzpt – standardised surface area of land use changes from open area into investment area between 1990 and 2000.

Based on the WWŚP and WPM indices a typology of the cities of Wielkopolska was defined, which distinguishes:

- cities where both the value of the natural environment and the pressure are above the average,
- cities where the value of the natural environment is above the average and the pressure is below the average,
- cities where both the value of the natural environment and the pressure are below the average,
- cities where the value of the natural environment is below the average and the pressure is above the average.

Spatial analyses were made using GIS techniques based on cartographic and statistical data. The timeframe of the analysis comprises data on valuable nature areas and city pressure from 1995 to 2006.

RESULTS

Location of cities with regard to natural assets

Among the 109 cities of the voivodeship of Wielkopolska the 1 km wide surrounding zone includes areas belonging to the country's ECONET network (55 cities), wildlife corridors linking NATURA 2000 areas (47 cities), CORINE biotopes areas (*subsites*) (27 cities), natural environment protection forms (national parks, landscape parks and reserves - 20 cities). Eight of the cities are situated in the vicinity of all the above area types. These are: Konin, Odolanów, Piła, Poznań, Puszczykowo, Pyzdry, Wągrowiec and Zagórow. In contrast, as many as 43 of the cities do not neighbour any of the listed valuable nature areas. Those are mainly cities located in the south western part of the voivodeship (fig. 1).

Valuable nature areas can be found around 66 cities of Wielkopolska, 42 of which have outstanding natural environment in the perspective of entire voivodeship. Cities with valuable natural environment are mostly located in the northern and central part of the voivodeship, which are characterised by significantly larger share of valuable nature areas than the south and south west.

The diversity of the natural environment value index for city surroundings was presented in tab. 1. The index is highest in the case of large cities, which primarily results from a larger absolute surface area of valuable nature areas. In contrast, the surroundings of middle-sized and small cities show clearly lower value of the natural environment.

Tab. 1. Diversity of natural environment value index for areas surrounding cities.

Cities	Areas				WWŚP index
	ECONET	CORINE biotopes (subsites)	Protected	Corridors linking NATURA 2000 areas	
Small ¹	-0.21	-0.09	0.14	-0.03	-0.19
Medium-sized ²	0.31	-0.09	-0.20	-0.24	-0.22
Large ³	0.99	1.57	-0.50	1.46	3.52
Poznań	2.32	0.21	-0.59	0.64	2.58

¹ Below 10,000 residents, ² from 10,000 to 50,000 residents, ³ above 50,000 residents excluding Poznań.

Source: author's study.

Characteristics of cities in respect of the pressure exerted on natural environment

The diversity of cities with regard to the pressure they exert on valuable nature areas is shown in fig. 2. Cities exerting a strong pressure concentrate in the central and southern parts of the voivodeship. Cities with the lowest pressure index are most numerous in the north and southern west.

As many as 44 cities in the voivodeship of Wielkopolska are characterised by a higher than average road density, 25 show larger than average surface area of areas used for investment and only in 16 of the cities the surface area of land cover changes (from open area into investment area) exceed the average. Only in Swarzędz and Poznań the density of population is above the average whereas the remaining cities are little different from each other and show a lower and similar value of this index. In the case of 48 cities four pressure features are below the average.

As shown in tab. 2, the weakest urban pressure is observable in small cities, where all factors analysed are below the average. Increased pressure can be noticed in larger cities, of which Poznań is most conspicuous. The cities exerting the strongest pressure are respectively: Poznań, Konin, Kalisz, Gniezno and Leszno, where investment is continuously expanding at the expense of open areas. Land cover changes are also a cause of strong pressure from small cities, such as Luboń and Swarzędz, in which the nearby Poznań spurs intensive urbanisation, or as in the case of Kleczewo, an increase of areas exploited by the lignite mine.

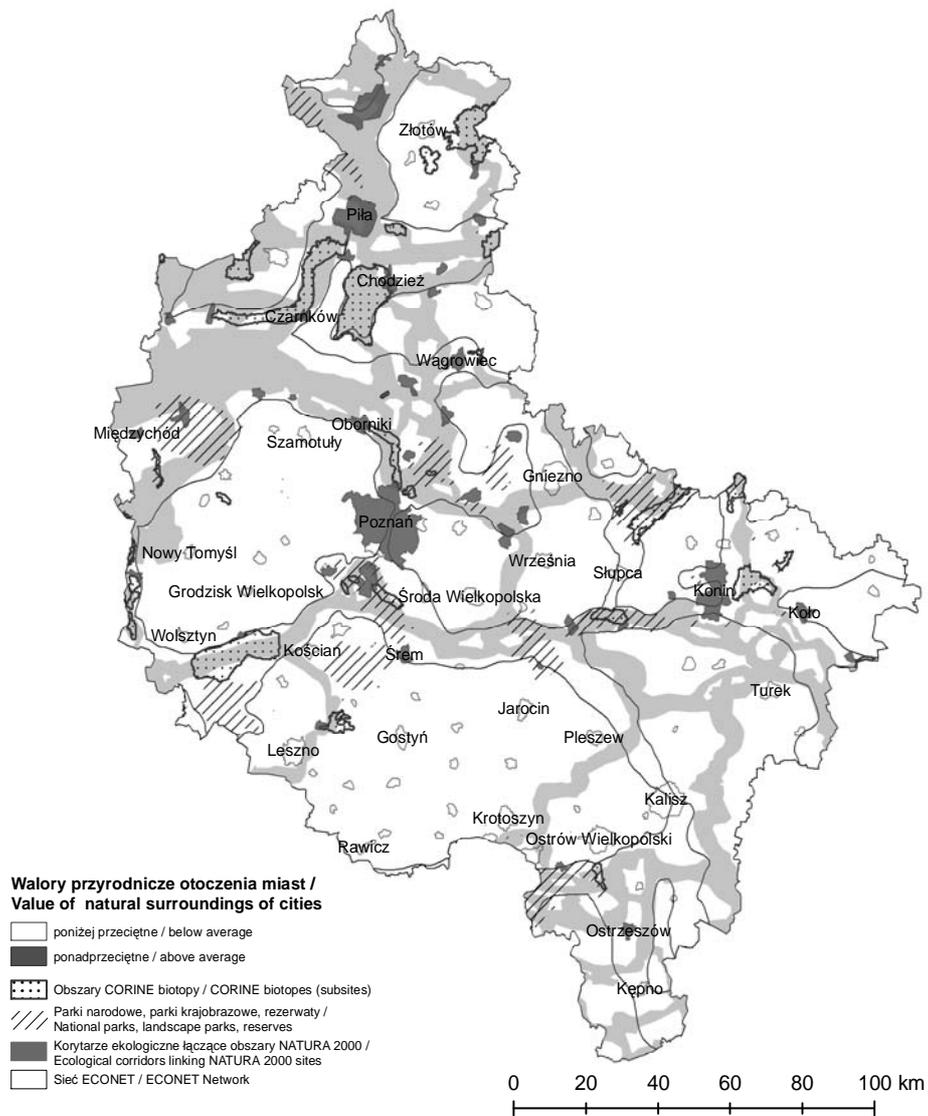


Fig. 1. Cities and areas with outstanding natural environment value

Source: Author's study based on data from (Jędrzejewski et al. 2005; Liro 1995; EEA 2001; Geo-environmental Map of Poland 2005).

Tab. 2. Diversity of urban pressure.

Cities	Features				WPM index
	Population density	Surface area of areas used for investment	Land cover changes	Road network density	
Small	-0.11	-0.25	-0.22	-0.21	-0.80
Middle-sized	-0.07	0.01	0.02	0.44	0.41
Large	-0.05	1.23	2.22	0.00	3.40
Poznań	0.00	9.66	1.95	1.49	13.10

Source: author's study.

Typology of cities

Based on the urban pressure index and the natural environment value index of city surroundings four types of cities were defined (fig. 3).

Type 1. Cities where both the value of the natural environment and the urban pressure are above the average.

As many as 15 cities in areas with higher than average value of the natural environment (in the perspective of the voivodeship) are characterised by an urban pressure index above the average. This group comprises cities with a clearly high natural environment value index and a relatively weaker pressure, and cities with a considerably less valuable surrounding natural environment and a stronger pressure. The latter are concentrated around the Poznań metropolitan area and scattered irregularly over the remaining area.

Among this type of cities are Poznań, the largest city of the voivodeship and the capital city, and two other large cities – Konin and Piła (former capital cities within the previous administrative division). Apart from the above, this group includes 6 medium-sized and 6 small cities. The strongest urban pressure in this group is exerted by Poznań and Konin, while the most valuable natural environment can be found in the surroundings of Puszczykowo, Piła and Mosina.

Type 2. Cities where the value of the natural environment is above the average and the urban pressure is below the average.

There are 26 cities where the urban pressure is below the average and the value of the surrounding natural environment is above the average. Such cities are mostly located in the northern part of the voivodeship. Out of the cities in this group Sieraków and Jastrowie are conspicuous because of the weakest pressure and most valuable natural environment in the surroundings. This group includes mainly small cities but also 6 middle-sized cities were noted.

Type 3. Cities where both the value of the natural environment and the urban pressure are below the average.

As many as 44 cities show lower than average value of the natural environment of the surroundings and a lower than average urban pressure. Such cities are concentrated in the southern west. The lowest urban pressure was observed in Dobra and Wysoka. The lowest environment value index was noted in 27 cities with no neighbouring valuable nature areas. The majority of cities in this category are small cities (35), and the rest are middle-sized cities.

Type 4. Cities where the value of the natural environment is below the average and the urban pressure is above the average.

As many as 24 cities are characterised by urban pressure above the average and are situated in areas where the natural environment value is lower than average. Those cities are concentrated in the western part of the voivodeship. The strongest pressure is exerted by Luboń and Kalisz. Most of the cities in this group are small (10) and middle-sized (10) but there are also 4 large cities, namely Kalisz, Leszno, Gniezno and Ostrów Wielkopolski.

Of 109 cities in Wielkopolska, 15 (type 1) are located in surroundings with outstanding natural environment value and show strong urban pressure, which is a consequence of intense investment. Those are: Golina, Koło, Konin, Mosina, Murowana Goślina, Ostrzeszów, Piła, Poznań, Puszczykowo, Stęszew, Śrem, Wągrowiec, Wielichowo, Zbąszyń and Żerków.

Type 2 cities, whose surroundings show highly valuable natural environment and where the pressure is weaker, have potentially the most favourable conditions for spatial links between the city nature system and the neighbouring areas. Cities with less valuable nature in their surroundings (types 3 and 4), because of little occurrence of neighbouring valuable nature areas, do not have a direct influence on the continuity of the nature system in the region. However, this indicates that such locations provide the least favourable conditions for a development of nature areas within the city and establishing a link with the surroundings. It may indicate a necessity to enrich or complement the nature system of cities with less valuable natural environment.

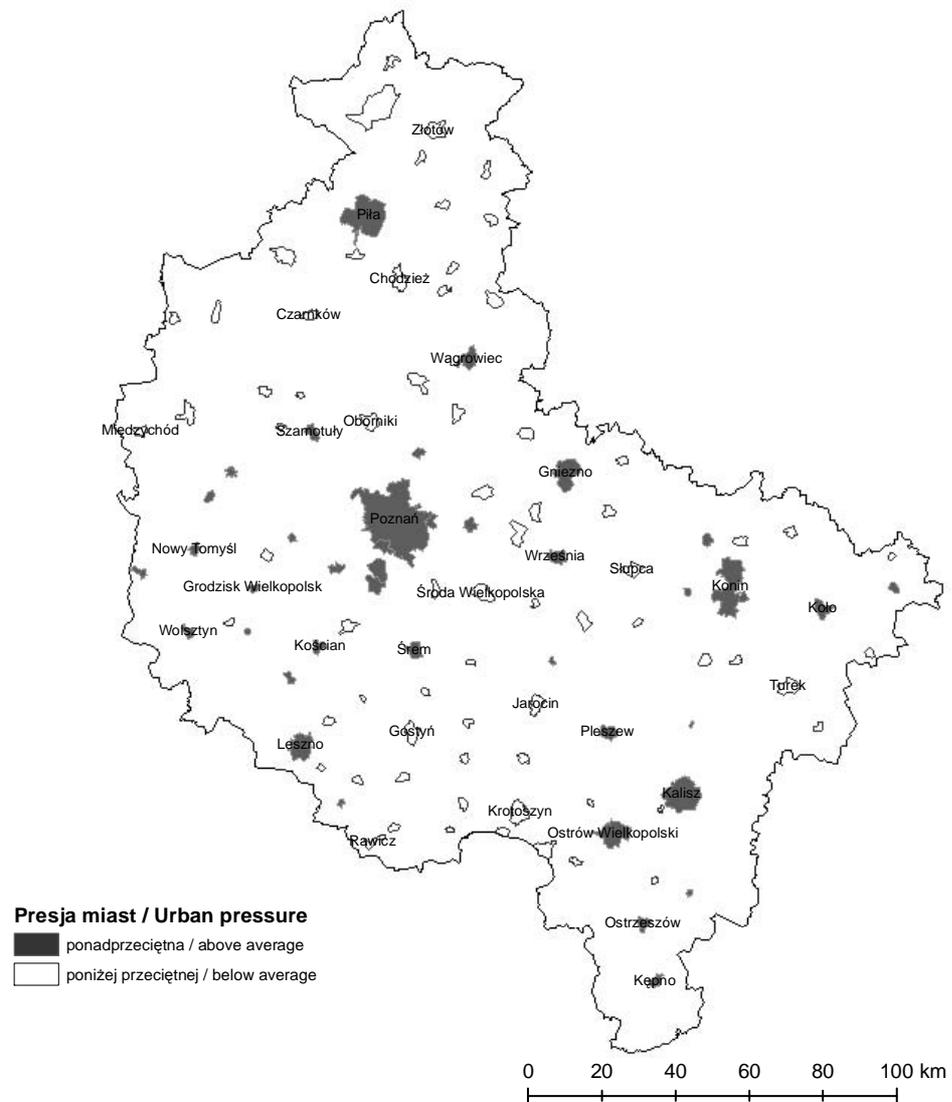


Fig. 2. Urban pressure exerted on valuable nature areas in the voivodeship of Wielkopolska
Source: author's study.

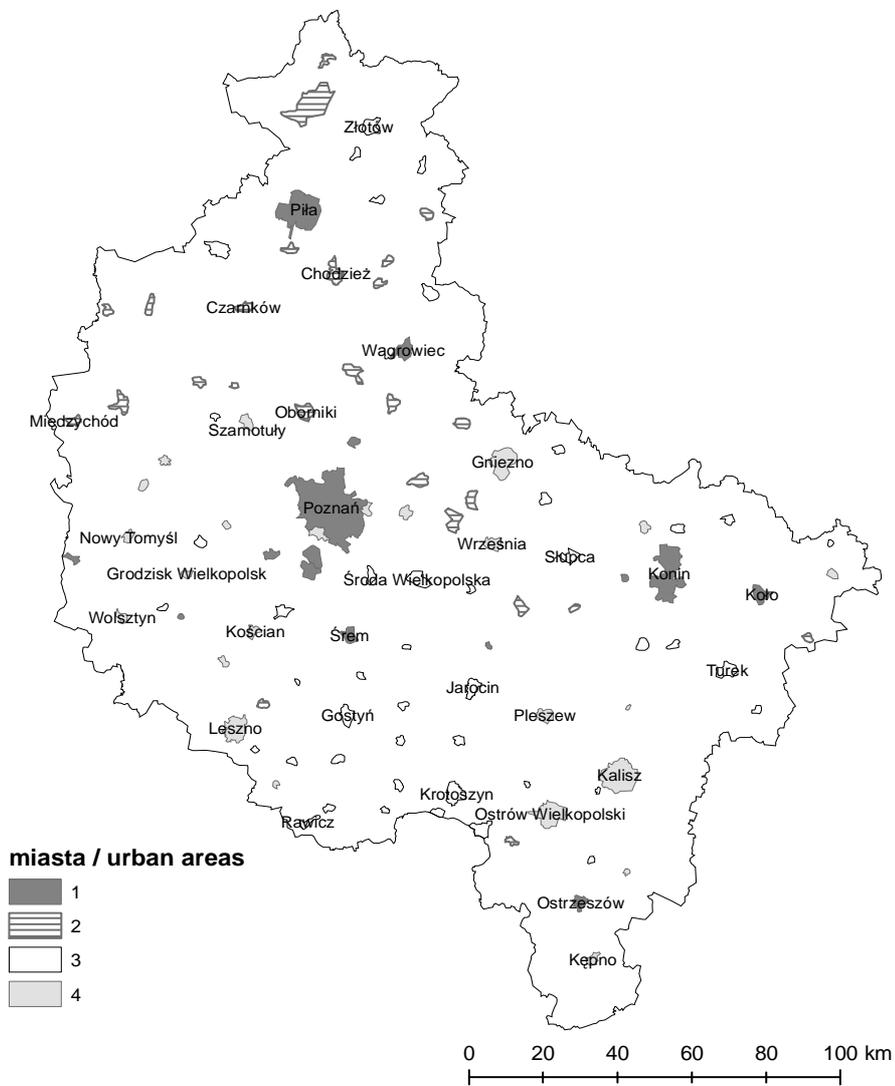


Fig. 3. Typology of cities.

1- cities where both the value of the natural environment and urban pressure are above the average; 2 - cities where the value of the natural environment is above the average and the urban pressure is below the average; 3 - cities where both the value of the natural environment and urban pressure are below the average; 4- cities where the value of the natural environment is below the average and the urban pressure is above the average. *Source: author's study.*

DISCUSSION AND CONCLUSIONS

The analysis performed permitted to differentiate 109 cities of Wielkopolska according to their location in relation to areas with highly valuable natural environment. Areas like ECONET, CORINE biotopes, wildlife corridors linking NATURE 2000 sites, national parks, landscape parks and reserves form the backbone of the voivodeship nature system and are important to the preservation of a diverse natural environment. Out of 42 cities surrounded by highly valuable natural environment, as many as 15 are characterised by a high urban pressure index. The intense development in the immediate surroundings of those cities may lead to the fragmentation and isolation of valuable nature areas making up the nature system and in consequence to the restriction or total breakage of its spatial connectivity. For those reasons type 1 cities were identified as those whose development should particularly take into account environmental conditions. Proper spatial management, not increasing the fragmentation of valuable nature areas, requires an appropriate policy both on the regional and local level.

The most vulnerable parts of the nature system, which if used for investment may endanger its continuity, should be identified in the regional spatial management plan as crucial for the preservation of the value and functionality of natural environment in the region. Also from the local planning perspective linking open areas within cities with more natural areas around them is important because it makes it possible to support the natural environment of those cities. However, as Polski (2007) argues the spatial planning system lacks links that would integrate the local and regional levels, which makes it inefficient. The relationships related to the cities with outstanding surrounding natural environment, which exert strong urban pressure on those surroundings, form a basis for the identification of instances of spatial interference that are of crucial importance to the regional spatial planning. Nevertheless, individual cities need more detailed studies which would determine the degree of fragmentation of valuable nature areas. Further analyses should focus especially on type 1 cities which, because of valuable natural environment in the surrounding areas and intensive investment, put the nature system of the voivodeship of Wielkopolska at the highest risk.

REFERENCES

- Ahern J., 1995: Greenways as a planning strategy. *Landscape and Urban Planning* 33, p. 131-155.
- Alberti M., Marzluff, J.M., 2004: Ecological resilience in urban ecosystems: Linking urban patterns to human and ecological functions. *Urban Ecosystems*, 7, ss.241-265.

- Andrzejewski R. 1986: Planowanie przestrzenne a środowisko przyrodnicze [Spatial planning and natural environment] [w:] Problemy ochrony i kształtowania środowiska przyrodniczego w planowaniu przestrzennym (red.): S. Kozłowski. Państwowe Wydawnictwo Ekonomiczne, Warszawa.
- Beatley T., 2004: Land Development and Endangered Species: Emerging Conflicts [w:] The Sustainable Urban Development. Routledge (eds.): S.M. Wheeler, T. Beatley. London-New York.
- Benedict M.A., McMahon, E.T., 2002: Green Infrastructure: Smart Conservation for the 21st Century. *Renewable Resources Journal* 20 (3), p.12-17.
- Breuste J., 2004: Decision making, planning and design for the conservation of indigenous vegetation with urban development. *Landscape and Urban Planning* 68, p. 439-452.
- Colinge S.K., 1996: Ecological consequences of habitat fragmentation: Implications for landscape architecture and planning. *Landscape and Urban Planning* 36, p. 59-77.
- EEA 1997 *CORINE Biotopes Sites - Database Status and Perspectives 1995*. Prepared by: Pinborg, U., Moss, D., Davies, C., Roy, D., European Environment Agency.
- EEA 2001 *Phare Topic Link and Nature conservation programme. Project: Strengthening Capacity in Accession Countries in Environmental Reporting Phare Topic Link on Nature Conservation. Corine biotopes polygon data*.
- EEA 2007 *Dane CORINE Land Cover 2000 (CLC2000) 100 m - version 9/2007*.
- Geneletti D., 2004: Using spatial indicators and value functions to assess ecosystem fragmentation caused by linear infrastructures. *International Journal of applied Earth Observation and Geoinformation* 5, p. 1-15.
- Główny Urząd Statystyczny, 2006. *Regionalna Baza Danych*.
- Hough M., 2004: *Cities and Natural Process: A Basis for Sustainability*. Routledge, London.
- Jędrzejewski W., Nowak, S., Stachura K., Skierczyński, M., Mysłajek, R.W., Niedziałkowski, K., Jędrzejewska, B., Wójcik, J.M., Zalewska, H., Pilot, M., 2005: Projekt korytarzy ekologicznych łączących Europejską Sieć Natura 2000 w Polsce. ZBS PAN, Białowieża.
- Kozłowski S., 2002: Ocena zrównoważonego rozwoju (ekorozwoju) w procesie transformacji polskiej gospodarki. Ekspertyza. Zeszyty Naukowe PAN nr 30, Warszawa.
- Liro A., 1995: *Koncepcja krajowej sieci ekologicznej ECONET-POLSKA*. Fundacja IUCN, Warszawa.

- Makomska-Juchiewicz M., 2007: O ochronie różnorodności biologicznej [w:] Integralna ochrona Przyrody (red.): M. Grzegorzcyk. Instytut Ochrony Przyrody PAN, Kraków, s. 55-68.
- Mapa Geośrodowiskowa Polski, 2005 Państwowy Instytut Geologiczny, Warszawa.
- Polski M., 2007: Systemowe Planowanie Przestrzenne a Ochrona Środowiska. Czasopismo Techniczne A, Architektura, z. 14 (104), ss.73-78.
- Zimny H., 2005: Ekologia miasta. Agencja Reklamowo-Wydawnicza Arkadiusz Grzegorzcyk, Warszawa.

SUMMARY

The purpose of this study was to classify the cities of the voivodeship of Wielkopolska with regard to the diverse value of the natural environment of their surroundings and the intensity of urban pressure exerted on them. Two groups of factors were analysed. The first group included factors related to the value of the natural environment of the city surroundings within a 1 km wide belt along the administrative boundaries of cities. In regard to this the following features were taken into consideration: the surface area and share of protected areas, the surface area and share of ECONET-PL areas, CORINE biotopes sites and wildlife corridors connecting NATURE 2000 sites. In the second part of the analysis, which concerned the urban pressure, the following factors were analysed: the population density in the urban fabric, the surface area of land used for investment, land cover changes from open into investment areas between 1990 and 2000, and the density of roads. As a result of the research conducted, 4 types of spatial relationships between cities and valuable nature areas in the voivodeship of Wielkopolska were distinguished. Among the cities whose surroundings have a valuable natural environment it was the cities exerting the strongest pressure on the regional nature system that were identified as causing the most severe spatial interference in the region.