

SELECTED INDEXES OF ANTHROPOGENIC IMPACT ON ENVIRONMENT IN THE WEST POLESIE BIOSPHERE RESERVE

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Summary. Created in 2002 West Polesie Biosphere Reserve is a region of particular natural values in European scale, as well as high touristic pressure. A large number of lakes and associated with it wide range of recreational place to choice makes Łęczna-Włodawa Lakeland as a significant region for tourists. The problem is even greater because the area subjected to the biggest touristic pressure, directly adjacent to many protected areas such as the Poleski National Park, nature reserves and NATURA 2000 sites. In the period from 1985 to 2008 tourist traffic in the area of Łęczna-Włodawa Lakeland rose more than 6 – fold which lead to degradation of many aquatic ecosystems. The present study shows that Białe Włodawskie Lake and Piaseczno Lake are the strongest load by touristic traffic. One of methods to relief the most valuable natural places and the most used by tourists lakes within West Polesie Biosphere Reserve is creation of several artificial recreational water bodies localized in C zone of Biosphere Reserve, in attractive for resting regions, but not recognized as highly nature valuable.

Key words: environmental index, anthropogenic load of environment, touristic traffic, West Polesie Biosphere Reserve, Łęczna-Włodawa Lakeland, tourism, population density

INTRODUCTION

The interest of tourists in places of outstanding natural values increases with intensification of urbanization's processes and a scale of anthropogenic landscape's transformation. This process is increasingly threatening of refugia of natural ecological systems. Created in 2002 West Polesie Biosphere Reserve is a region of particular natural values in European scale, as well as high touristic pressure. An area of nearly 140 000 ha covers almost the whole physiographic mesoregion of the Łęczna-Włodawa Lakeland and stretches from the Bug river below Wola Uhruska in the south-east to the Siemień Ponds in the Tyśmienica

river valley in the north-west [Chmielewski (ed.) 2005]. In terms of administration Biosphere Reserve is wholly situated within the Lublin voivodship. There is a great variety of aquatic ecosystems, peatbogs, forests, meadows and cultivated fields forming as a labyrinthine system of different hydrographic, geochemical, soil and biocenotic conditions and various degree of anthropogenic land transformation [Chmielewski (ed.) 2005].

Łęczna-Włodawa Lakeland is the largest in Poland grouping of lakes occurring outside the areas formed by glacial morphogenesis of the last glaciation. Physiographic features of Polish lowland and upland zone create a special and unique mosaic of natural phenomena. This area is characterized by landscape of plain accumulation located in watershed zone of Bug and Wieprz rivers. A process of river valleys' formation on this area occurs barely in a initialised stage, which gives geomorphological character of youth to this area [Wilgat (ed.) 1986].

Due to poor soil and a large part of wetlands and forests, the area of Łęczna-Włodawa Lakeland is relatively poorly populated and extensively economically used. However, due to the grouping of over 60 lakes, it is an attractive holiday destination for people coming from surrounding towns for a weekend or several days. A large number of lakes and associated with it wide range of recreational choice makes Łęczna-Włodawa Lakeland as a significant region for tourists. A strong development of recreational zone is strongly visible, often directly neighboring to valuable aquatic ecosystems. This touristic infrastructure is forming with chaotic way, breaking generally accepted principles of aesthetics, in most cases without cooperation with landscape architects. Representing various styles, materials and ideas of various neighbors this kind of chaotic infrastructure doesn't conducive to protect regional character of place [Chmielewski 2001a, Chmielewski (ed.) 2009].

The problem is even greater because the area subjected to the biggest touristic pressure, directly adjacent to many protected areas such as the Poleski National Park, nature reserves and Natura 2000 sites. This linkage of protected areas with high concentration of touristic traffic is described as so-called MacCannell's effect [2002]: at the same time protected areas are becoming a tourist attraction, the determinant of supply tourism, and increasing tourist traffic destroys values that it generates.

The area of the West Polesie Biosphere Reserve constitutes place of converge and crossing of several important ecological corridors [Chmielewski 2001a]. Gerlée and Kaim [2010] observed that areas with the highest abilities to fulfill functions of ecological corridors and touristic functions in many cases overlap, that's why sustainable development of such areas is so important in order to avoid conflicts or ecosystems' degradation.

With occurrence of road infrastructure in touristic areas two drawbacks are related: roads constitute a barriers for plants and animals' migration and facilitate penetration of the area by motorized tourists.

Taking into account ways of tourism's impact on natural environment studies can distinguish several types of interactions:

- physical (mechanical) impact as a result of people's movement and technical equipment on the ground;
- chemical impact, arising as a result of secretion into the environment different types of chemicals;
- biological impact, consisting on introduction or elimination of organisms from their natural system;
- technical impact, including various forms of human interferences, such as various types of buildings, technical infrastructure, reclamation of degraded zones, introduction of garden art in places of natural systems [Krzyszowska-Kostrowicka 1999].

The consequence of mass and individual tourism is caused by destruction of plants by breaking and treading, eutrophication of the environment as a result of sewage passage from leaking sewers and sanitary landfills, disturbance of wildlife animals and strong synanthropization of plants [Mielnicka 1991]. In the period from 1985 to 2008 tourist traffic in the area of Łęczna-Włodawa Lakeland rose more than 6 – fold [Chmielewski and Jankowska 2009] and it significantly threatens of ecological values of the Biosphere Reserve.

The aim of the study was to identify regions of the West Polesie Biosphere Reserve with the largest scale of anthropogenic load of environment and to propose solutions to reduce this threat.

MATERIALS AND METHODS

The method of counting indexes of environmental impact developed T.J. Chmielewski [2001b] and together with a team of colleagues analyzed their values for 20 lakes' catchments in the area of Łęczna-Włodawa Lakeland [Chmielewski *et al.* 2006].

In this paper two selected indexes of anthropogenic environmental impact are presented: W1 – population density according to village area, W2 – size of touristic traffic; with regard to whole area of the Biosphere Reserve. Data concerning borders of individual villages and number of inhabitants in 2011 year obtained from municipalities within the borders of the Biosphere Reserve West Polesie. Based on these data indexes of population density were calculated for individual villages. Borders of individual villages were brought on the map in 1:50 000 scale in ArcGIS 10.0. This program also calculated surfaces of individual villages. Surfaces of municipalities within the borders of the Biosphere Reserve were calculated cartometrically in ArcGIS 10.0. Data concerning number of inhabitants of villages were available in offices of municipalites. Data concerning size and structure of tourism derived from papers: Chmielewski [2001b] and Chmielewski and Jankowska [2009]. On some lakes measurements were also made in August 2011 (unpublished). Size of touristic traffic in the area was

Table 1. Summary of surfaces and number of inhabitants of municipalities and numbers of individual villages within borders of the West Polesie Biosphere Reserve

Municipality	Surface, ha	Number of villages	Number of inhabitants
Chełm Province			
Sawin	3 647	3	583
Wierzbica	10 676	2	167
Lubartów Province			
Ostrów Lubelski	6 102	5	3 943
Uścimów	11 059	12	3 602
Łęczna Province			
Cyców	1 262	2	406
Ludwin	10 104	17	4 493
Łęczna	660	1	173
Parczew Province			
Dębowa Kłoda	7 678	4	1 010
Parczew	5 661	7	1 403
Siemień	6 608	11	3 182
Sosnowica	16 736	12	2 767
Włodawa Province			
Hańsk	17 453	16	4 148
Stary Brus	10 542	12	1 881
Urszulin	17 509	25	4 319
Włodawa	14 527	6	2 035
Wola Uhruska	11 684	11	1 494
Wiryki	10 254	4	928
Total	162 162	150	36 534

Source: Own elaboration on base on data given by municipalities offices and cartometrical measurements in ArcGIS 10.0.

Table 2. The scale of anthropogenic impact on lakes, as a result of touristic traffic

Lakes	Number of tourists	Index of anthropogenic impact on environment
Bikeze, Brudno, Brudzieniec, Długie, Dratów, Dubeczyńskie, Kosieniec, Krzcień, Łukie, Maśluchowskie, Moszne, Nadrybie, Perespa, Płotycze Urszulińskie, Płotycze Sobiborskie, Uścimowiec, Wspólne	0–50	1
Czarne Sosnowickie, Czarne Włodawskie, Głębokie	51–100	2
Sumin, Ściegienne	101–200	3
Kleszczów, Mytycze, Rogóžno, Tomaszne	201–400	4
Miejskie, Uściwierz, Wytyckie	401–800	5
Glinki	801–1600	6
Krasne, Łukcze	1601–3200	7
Bialskie, Białe Włodawskie, Piaseczno, Zagłębcze	>3200	8

Source: Own elaboration on base on Chmielewski [2001] measurements and Chmielewski and Jankowska [2009], with complementary research made in August 2011 (unpublished).

calculated at chosen lakes, as well as in belt of land within a radius of 1km from the lake shore by method called „instantaneous measurement” [Chmielewski 2001b]. For the classification of villages the following scale was used: 0.01–0.02, 0.021–0.04, 0.041–0.08, 0.081–0.16, 0.161–0.32, 0.321–0.64, 0.641–1.28, 1.281–2.56. Next each interval were given valuation points, respectively from 1 to 8.

The second index: size of touristic traffic was calculated on base of number of tourists visiting lakes and their surroundings (Tab. 2). Scale was developed to classify lakes according to the number of visitors (following scale was used: 0–50, 51–100, 101–200, 201–400, 401–800, 801–1600, 1601–3200, above 3200). Next each interval were given valuation points, respectively from 1 to 8.

Next points obtained by individual villages in both ranges were sum up. Both indexes of environmental load were treated equally, because both refer to number of people using environmental resources and the overall number of permanent residents of the study area is comparable with the total number of tourists staying here. In case when lake and its surrounding belt of land within a radius of 1km were on the area of several villages, the number of tourists assumed proportional to the percentage of lake’s recreational area in the village. The results of the analysis are presented on maps generated in environment of ArcGIS 10.0.

RESULTS

Data concerning surfaces and number of inhabitants of municipalities and numbers of individual villages within borders of the West Polesie Biosphere Reserve are present in Table 1, while indexes of population density in individual villages on Fig. 1.

Generally, population density in the area of the Biosphere Reserve is not high. Villages characterized by the highest index of population density are grouping in the west and in the south part of the Biosphere Reserve, in range of impact of urbanization’s processes of Lublin Metropolis. Villages with index W1 equal 7 and 8 points together cover 7% of the whole area of the West Polesie Biosphere Reserve.

Results of anthropogenic load’s evaluation of lakes as a result of touristic traffic presents Table 2 and Fig. 2.

The highest recreational movement concentrates in a few regions, where there are the most attractive for relax mesotrophic lakes. Five of these regions are located in the west part of the Biosphere Reserve, one in its central part and one in the east part. In total villages with index W2 equal 7 and 8 points together cover 8% of the whole area of the West Polesie Biosphere Reserve.

Values of summary index of anthropogenic load of environment, which includes population density and size of touristic traffic in individual villages shows Fig. 3.

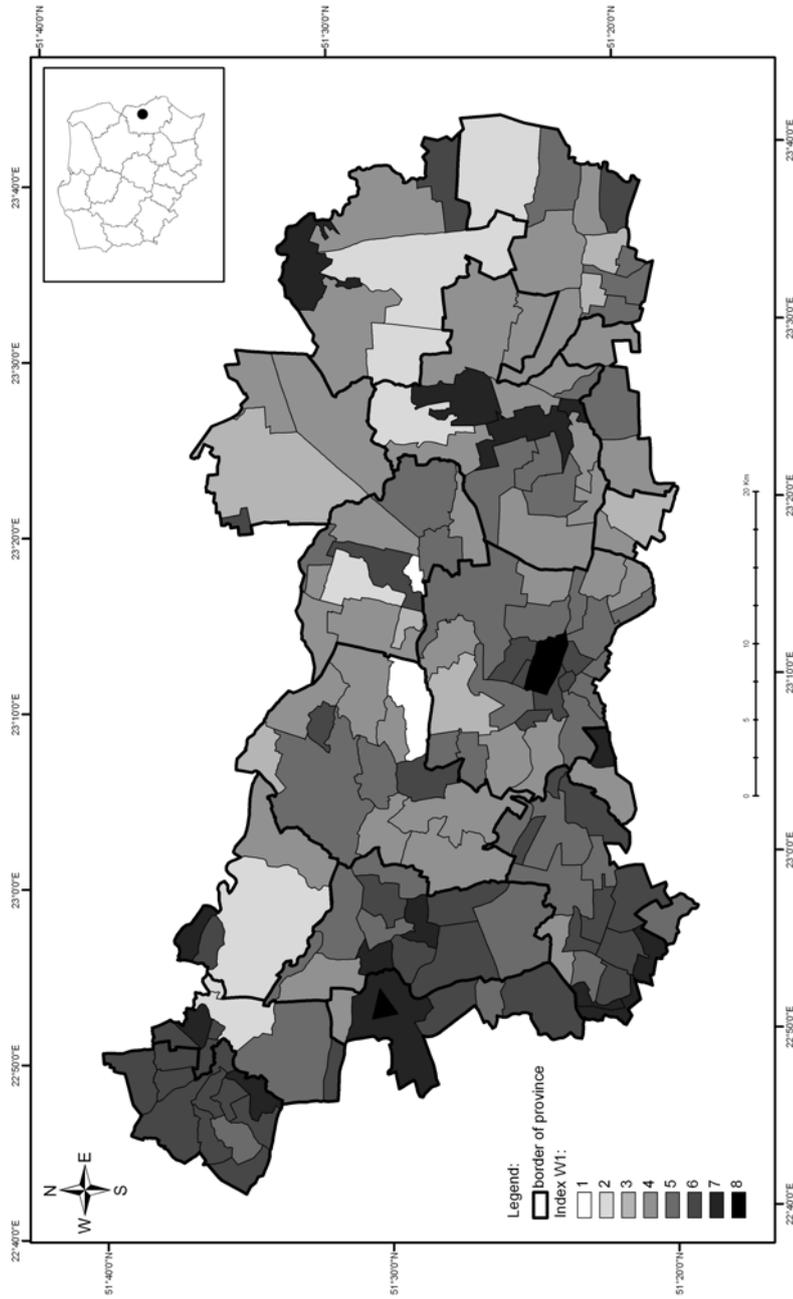


Fig. 1. Cartogram of population density in individual villages in the West Polesie Biosphere Reserve

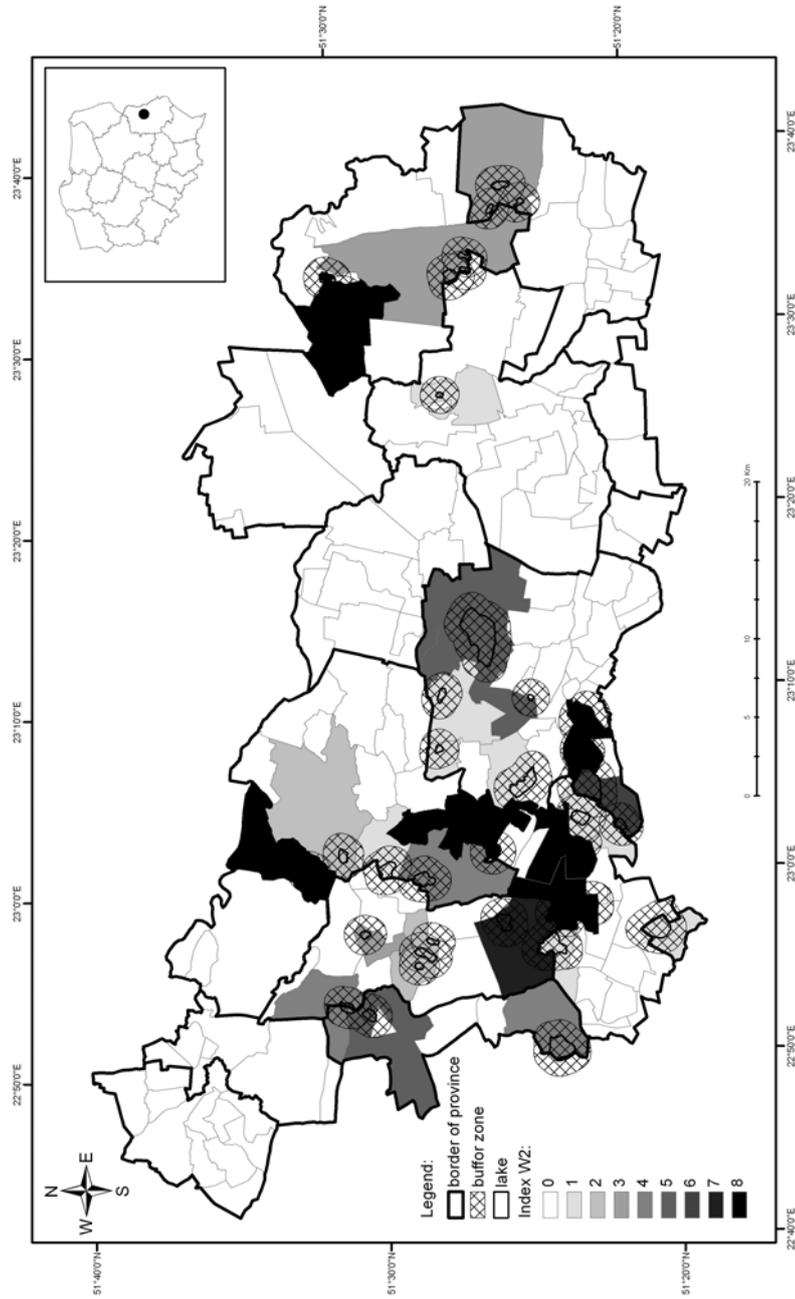


Fig. 2. Cartogram of anthropogenic impact of touristic traffic on individual lakes and their surroundings in borders of villages in the West Polesie Biosphere Reserve

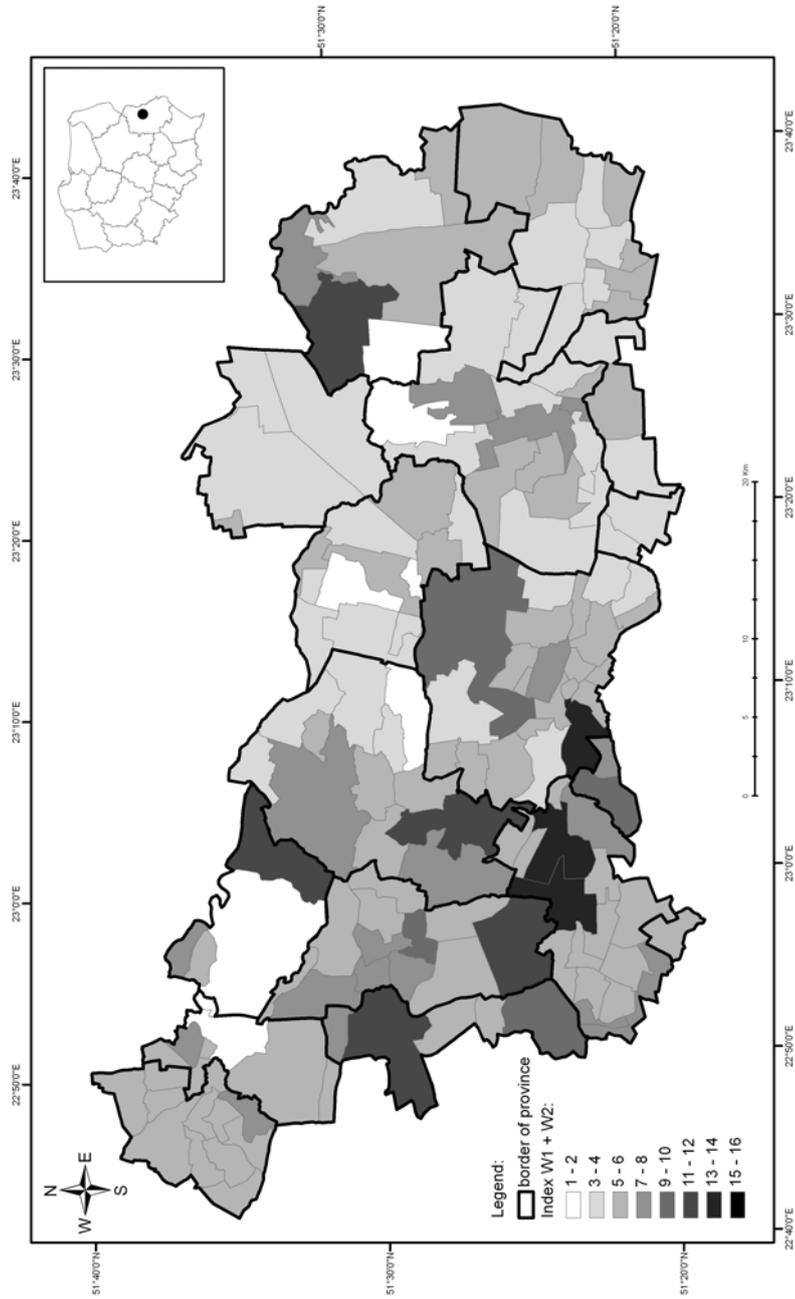


Fig. 3. Cartogram of summary index of anthropogenic impact on environment at individual lakes and their surroundings in borders of villages in the West Polesie Biosphere Reserve

The highest summary index of anthropogenic load of environment (13–16) is characteristic for the following villages: Grabniak, Piaseczno and Rogóżno. They covers 2% of whole area of the Biosphere Reserve. These villages are concentrated mainly in west part of the West Polesie Biosphere Reserve.

The lowest summary index of anthropogenic load of environment (1–4) is characteristic for the following villages: Adampol, Buradów, Hańsk Drugi, Józefów, Laski Bruskie, Kamień, Karczunek, Kosyń, Kulczyn, Las Bukowski, Lipnik, Lubowież, Luta, Macoszyn Duży, Macoszyn Mały, Majdan Stuleński, Makoszka, Marianka, Mietułka, Mszanna Kolonia, Nowiny, Nowy Brus, Olchówka, Osowa, Pieszowola, Podpakule, Serniawy, Sęków, Sobibór, Stary Majdan, Suchawa, Szczęśniki, Tarnów, Turno, Wielopole, Wincencin, Wojciechów, Wola Wereszczyńska, Wołoskowola, Wiryki, Zatlucze Stare, Zbójno, Żdżarki, which together cover 35% of the whole area of the West Polesie Biosphere Reserve. Mostly there are areas of extensive forest and peatbog complexes.

Particularly, the most negative for management of natural resources of the Biosphere Reserve is significantly anthropogenic load of environment in the central part of studied area (Wytyckie Lake region) and in the middle-west part (Zagłębobcze Lake region), because of fact that they surround particularly valuable natural complexes of Poleski National Park. Isolated and insular region of high anthropogenic load of environment occurs also in the north – east edge of the West Polesie Biosphere Reserve – near Włodawa District.

Ways of reducing of anthropogenic load of environment' scale Reducing of anthropogenic load of environment' scale can be followed by:

- concentration of invests in settlements, counteract of buildings' disperse in open landscape, stopping of buliding valuable natural ecosystems and their surroundings;
- development of technical infrastructure linked with environment' preservation (sewage systems, sewage treatment plant, system organization of waste's management, gasification of settlements);
- integration of technical infrastructure (building roads, power line systems and medic collectors by shared „infrastructures corridors”, saving natural and recreation space);
- restoration and natural enrichment of negative modified ecosystems, particularly aquatic – peatbog;
- particular preservation of knots system and ecological corridors and increasing of cohesion of ecological landscape systems;
- increasing of forest share (with exclusion of forestation of natural valuable not-forest ecosystems);
- relief of natural valuable areas from excessive touristic traffic, mainly by building new objects and facilities in the most attractive recreational areas but not nature unique (e.g. creation of new water bodies with recreational function, which relief natural lakes from touristic traffic pressure);
- concentration of touristic traffic on defined routes by determination touristic routes and educational paths, which are attractive in landscape and touring

ways, but avoid the most valuable natural refuges [Chmielewski 2001a, 2011, Chmielewski *et al.* 2006].

In relation to the West Polesie Biosphere Reserve preservation and renaturalization activities should be concentrated in chosen settlements of C Zone of the Biosphere Reserve [Chmielewski (ed.) 2005].

In case of the West Polesie Biosphere Reserve there are some the most convenient regions to localize artificial water bodies with recreation function like:

- the Tyśmienica river valley in region of Krasne village (with extra powering from Wieprz-Krzna Channel);
- the Tyśmienica river valley near Ostrów Lubelski;
- the Piwonia river valley in region of Orzechów Stary village (with extra powering from Wieprz-Krzna Channel);
- the Piwonia river valley near Sosnowica village (with possible powering from Wieprz-Krzna Channel);
- the Włodawka river valley near Włodawa City.

CONCLUSIONS

1. The West Polesie Biosphere Reserve is a region poorly populated and extensively economically used, but it is subject to increasing touristic traffic's pressure, particularly strong in its south – west and north – east sector.

2. The highest summary index of anthropogenic impact on environment is characteristic for three villages: Grabniak, Piaseczno and Rogóżno. They covers 2% of whole area of the Biosphere Reserve.

3. The lowest summary index of anthropogenic impact on environment is characteristic for forty – three villages, which together cover 35% of the whole area of the West Polesie Biosphere Reserve.

4. One of methods of natural valuable aquatic ecosystems' relief from excessive touristic pressure can be creation of several artificial recreational water bodies localized in river valleys in C zone of the Biosphere Reserve.

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WYBRANE WSKAŹNIKI ANTROPOGENICZNEGO OBCIĄŻENIA ŚRODOWISKA W REZERWACIE BIOSFERY POLESIE ZACHODNIE

Streszczenie. Powstały w 2002 r. Rezerwat Biosfery Polesie Zachodnie jest miejscem szczególnych w skali Europy walorów przyrodniczych, jak i wysokiej presji turystycznej. Duża liczba jezior i związany z nią szeroki wachlarz wyboru miejsc rekreacyjnych czyni ten region wysoce atrakcyjnym turystycznie. Problem jest tym większy, że obszary poddane największej presji turystycznej często bezpośrednio sąsiadują z wybitnie cennymi kompleksami ekologicznymi, takimi jak Poleski Park Narodowy, rezerваты przyrody oraz obszary NATURA 2000. W okresie 1985–2008 nastąpił tu ponad 6-krotny wzrost ruchu turystycznego, prowadzący do degradacji wielu ekosystemów wodnych. Z przeprowadzonych badań wynika, że najsilniej obciążone ruchem turystycznym są jeziora: Białe Włodawskie oraz Piaseczno. Należy odciążyć najcenniejsze przyrodniczo oraz najsilniej turystycznie użytkowane jeziora w obrębie Rezerwatu Biosfery Polesie Zachodnie, budując zbiorniki rekreacyjne w strefie C Rezerwatu Biosfery, w rejonach atrakcyjnych dla wypoczynku, ale nieuznanych za wybitnie cenne przyrodniczo.

Słowa kluczowe: wskaźniki środowiskowe, antropogeniczne obciążenie środowiska, ruch turystyczny, Rezerwat Biosfery Polesie Zachodnie, Pojezierze Łęczyńsko-Włodawskie, turystyka, gęstość zaludnienia