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## The cartographic visualisation of spatial data. An example of nature protection areas in the Podlaskie Voivodship (north-eastern Poland)

**Abstract.** The authors attempt to visualise nature conservation issues in the Podlaskie Voivodship using a series of small-scale thematic maps. Publicly available spatial and statistical data was used. The authors discuss the effects of applying the adopted methodological solutions. Some of them present a new approach to cartographic visualisation of spatial data. It may be an opportunity to look at various visualisation methods, their effectiveness, and the possibility of visualising nature issues on small-scale thematic maps.

**Keywords:** cartographic visualisation, cartographic visualisation techniques, thematic map, nature protection, the Podlaskie Voivodship

### 1. Introduction

According to the dictionary definition (L. Drabik, E. Sobol 2007, p. 407), visualisation involves “presenting something by means of an image”. This very general statement has acquired a new meaning in recent decades, also in relation to cartography. The graphical presentation of data is only one of the components of the visualisation process, which aims to provide a better understanding of spatial processes and relationships through the increased possibilities of various analyses using dynamically developing computer technologies. Examples of publications from the end of the last century contributing to the development of cartographic visualisation include works by H.M. Hernshaw, D.J. Unwin 1994; A.M. McEachren, D.R.F. Taylor 1994; M-J. Kraak, F. Ormeling 1996. Cartographic visualisation facilitates reading data (J. Jovanović 2012), and we can acquire knowledge about our surroundings in a more effective way (T. Slocum et al. 2005). According to B. Medyńska-Gulij (2011, p. 13), cartographic visualisation is “the process of creating graphic presentations, most often in the form of a map, in order

to learn and explain the occurring spatial phenomena”.

Since maps are one of the sources of information about nature, as they show its condition, threats, and forms of protection, it is possible to analyse what happens in nature at various scales – from large-scale thematic maps, through overview maps, tourist maps, to small-scale maps in geographic atlases. The Podlaskie Voivodship is undoubtedly a good area for such analyses. This article provides an opportunity to look at the region’s natural wealth from the perspective of small-scale thematic maps, which is possible thanks to an abundance of source materials. The article can also be treated as a voice in discussions conducted by cartographers on the possibilities of cartographic presentation methods used in small-scale thematic maps (P. Fabijańska, J. Korycka-Skorupa 2018; K. Medolińska et al. 2018).

### 2. The range of research

The Podlaskie Voivodship is located in north-eastern Poland (fig. 1). There are valuable areas of marshes in the valleys of the Narew

and Biebrza rivers, which are one of the largest refuges of wild flora and fauna, not only in Poland, but also in Europe. The region also includes numerous forest areas, such as the Knyszyn and Augustów Forests, and the Białowieża Forest, which is on the UNESCO World Natural Heritage List, where the remains of the oldest primeval forest in Europe have been preserved. There are also numerous lakes in the north of the voivodship, including Hańcza Lake, the deepest in Poland.



Fig. 1. The location of the Podlaskie Voivodship in Poland

Due to the unique natural values of the region, four national parks have been established here: The Białowieża National Park (the oldest in Poland), the Wigry National Park, the Biebrza National Park (the largest in Poland), and the Narew National Park, as well as three landscape parks. In addition, there are 93 nature reserves, 13 protected landscape areas, 35 "Natura 2000" areas, 1998 natural monuments, and many other forms of protection. In total, almost 40% of the Voivodship's area is under protection (Statistical Office in Białystok 2017a). The Podlaskie Voivodship has the largest percentage of national parks in Poland and is the second largest in terms of the "Natura 2000" areas.

### 3. Nature protection of the Podlaskie Voivodship on small-scale thematic maps

Conservation issues are important and always included in geographical atlases. Polish cartographic publications include national atlases [A1, A2], numerous school atlases, e.g. [A6, A7], atlases devoted to the natural environment of the country [A3], and selected regions [A4, A5].

In the national atlases of Poland, the subject of nature protection has been presented on maps of the whole country at the scale of 1:2,000,000 and 1:1,500,000. The following protected areas are shown in this way: national parks, landscape parks, protected landscape areas, reserves and natural monuments in various categories. In the *Atlas of the Republic of Poland* [A2], the World Biosphere Reserves and the "Green Lungs of Poland" are also shown on a separate map.

The natural environment of the whole country has been extensively presented on 1:2,000,000 maps in the *Atlas of resources, values and threats to the geographical environment of Poland* [A3].

In the *Atlas of the Białystok Voivodship* [A4] (similar in area to today's Podlaskie Voivodship), nature protection was only included in the 1:300,000 *Tourism* map. Reserves and strict reserves according to their type are shown.

In 2018, the Statistics Poland published a series of sixteen statistical atlases of Polish voivodships (M. Zych, K. Medolińska 2018), including the *Statistical Atlas of Podlaskie Voivodship* [A5]. Only one map in the scale of approx. 1:1,200,000 concerns issues related to nature protection – the share of legally protected areas in relation to communes (basic administrative units) is shown.

Many issues related to nature protection can be found on the official portal of *Wrota Podlasia (The Gateway to Podlasie)* (wrotapodlasia.pl; as of May 11, 2020) and in its cartographic part *GIS dla Podlasia [GIS for Podlasie]* (geoportal.wrotapodlasia.pl; accessed May 11, 2020). These are maps in topographic and overview scales, presenting protected landscape areas and "Natura 2000" areas.

Small-scale maps of protection and threats to the natural environment of Podlasie are included in *Raport o stanie środowiska województwa podlaskiego 2015 (Report about condition of the Podlaskie Voivodship's environment 2015)*, available on the website of the Chief Inspecto-

rate for Environmental Protection. These are thematic maps similar in scale to those that are the subject of this article (scale of approx. 1:1,200,000).

A query of maps in the field of nature protection was also used to analyze the thematic content, which included nature reserves, protected landscape areas, nature monuments, and other forms of nature protection provided for in the law. Their base map content is standard: rivers, reservoirs, towns, and administrative boundaries.

Among the cartographic methods used in such maps, the most common is the chorochromatic method, used to show objects with a relatively large area, e.g. forests, national parks, and landscape parks. The symbol map is used to represent objects with a point reference, such as reserves or natural monuments. The choropleth map shows quantitative indicators related to enumeration units, most often administrative units.

As can be seen from the review of cartographic studies on nature protection in the Podlaskie Voivodship, this issue is mainly shown on maps of the whole country, i.e. small-scale maps. The task of the authors of the article is to look at the availability of source data suitable for the elaboration of maps on such scales and visualise them using proven methods and to propose new solutions.

#### **4. Data and methodological assumptions of maps**

The first stage of elaborating a series of maps of the Podlaskie Voivodship was to collect, organise, and verify publicly available data from various sources (fig. 2). The vector data was collected from two databases provided by the Head Office of Geodesy and Cartography: State Register of Borders and Area of Territorial Units of the Country (vector layers with administrative boundaries) and the General Geographic Objects Database (layers with forests and surface waters). Another data source was the website of the General Directorate for Environmental Protection, from which layers with forms of nature protection were downloaded. The statistical data was provided by the Statistical Office in Białystok (2017a, 2017b).

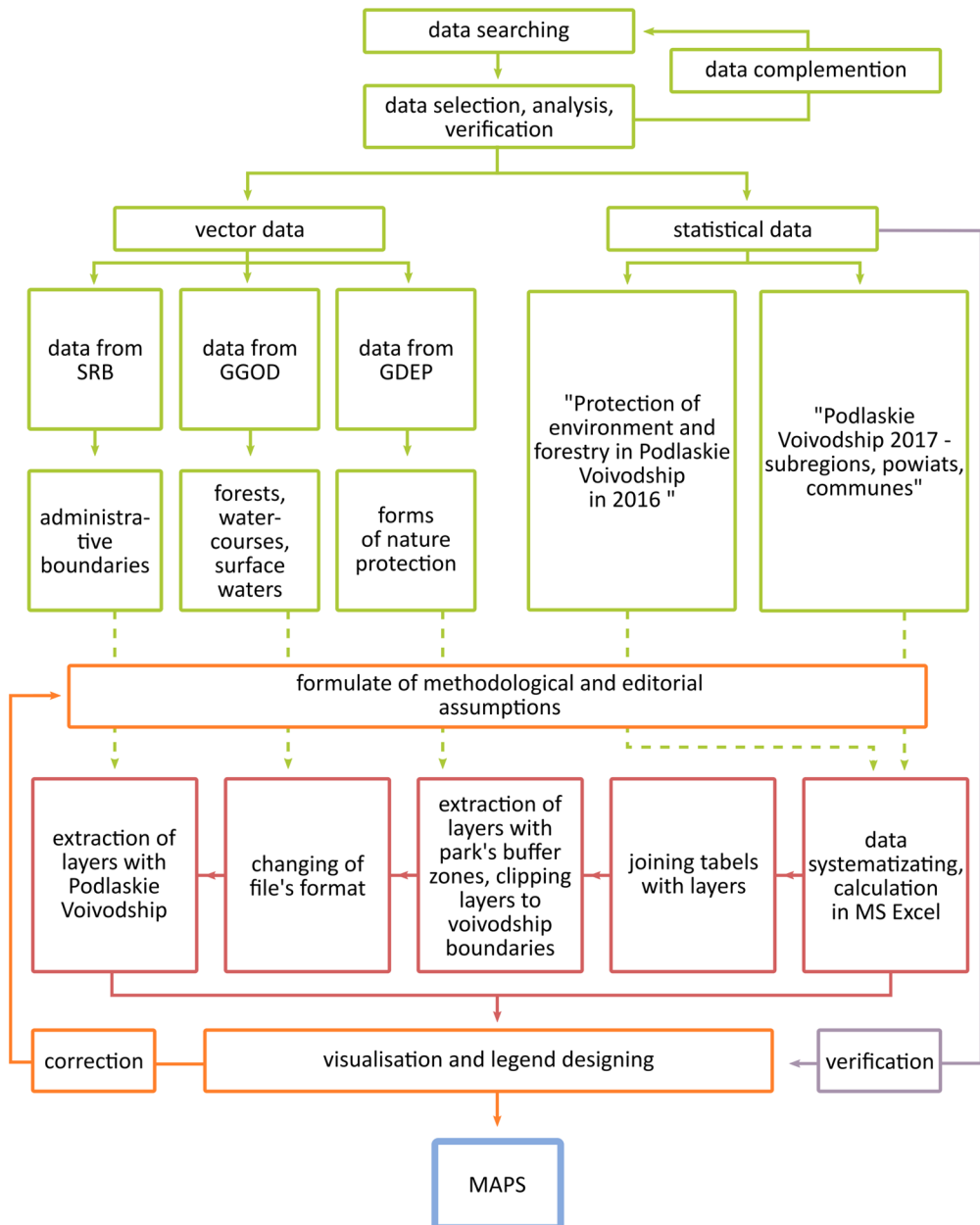
The next step was to formulate the methodological and editorial assumptions of the maps.

It is a very important stage in every editorial process, because good maps are simple, legible, without methodological mistakes (J. Korycka-Skorupa 2015). When preparing a series of maps on a given topic, it is also necessary to ensure that they are coherent, both thematically and graphically (V. Voženilek, J. Kaňok 2011), and that their thematic and base map content is properly and equally generalised (P. Cebryk 2017). The maps were prepared at the scales 1:1,500,000 and 1:2,500,000 (graphically simple choropleth maps). The content of the maps has been limited to the area of the voivodship due to both data availability and the uniformity of the map series.

A key stage in formulating the methodological assumptions was the selection of appropriate cartographic methods. The choice of methods resulted primarily from the analysis of the available data: from the method of their reference – to a point, line or surface, as well as their nature (relative or absolute data) and the method of presentation (continuous or interval, i.e. divided into classes) (J. Korycka-Skorupa 2002). While elaborating the maps, efforts were made to use various possibilities of cartographic presentation, both qualitative methods – chorochromatic and symbol, as well as quantitative ones – a proportional symbol map and a choropleth map were used. Ordered levels were not used, as they were considered to be an overly generalised form of statistical information. The presentation methods were selected so that the data was presented in a varied, interesting, and as comprehensive manner as possible for the user.

After collecting the data and selecting the cartographic methods, it was necessary to transform the data to the needs of visualisation, and thus to process them (also referred to as “transformation”) (J. Korycka-Skorupa 2002). The processing of vector data downloaded from General Geographic Objects Database consisted in “technical” activities performed in the ArcMap 10.5 program, which included clipping the forest layer to the voivodship boundaries and arranging the order of thematic layers. Statistical data required ordering and sometime changing the spatial reference, as well as preparing distribution plot in order to determine classes.

The next step in elaborating the map was designing the symbols and preparing legends.



SRB - State Register of Borders and Area of Territorial Units of the Country  
 GGOD - General Geographic Objects Database  
 GDEP - General Directorate of Environmental Protection

Fig. 2. The methodological scheme of map elaboration process

The graphic symbols of the objects presented on the maps were selected so that they were associated with the presented objects, legible, and distinguishable (B.D. Dent et al. 2009). An important step in the process of elaborating a map, especially a thematic map, is designing a legend, especially when it contains symbols not always intuitively recognised by users (I. Gołębiowska 2015). The content related to nature protection has been arranged in a legend in a logical order: national parks (along with buffer zones), landscape reserves and parks, and forms of protection allowing for increasing human interference in the environment. This order refers to the *Ustawa o ochronie przyrody* (2004) [Act on the protection of nature]. The maps were elaborated in ArcMap 10.5. and Corel Draw X6. The justification of the adopted methodological solutions is discussed further in the article.

### 5. Small-scale thematic maps of the Podlaskie Voivodship

Figure 2 shows a diagram which was used to elaborate a series of eleven small-scale thematic maps and a diagram showing nature protection in Podlaskie Voivodship. It is an attempt at an exhaustive cartographic presentation of generally available data on this issue, carried out at scales of 1:1,500,000 and 1:2,500,000.

#### Area protected by the law

The series begins with a map at a scale of 1:1,500,000, which shows areas under legal protection (fig. 3). The chorochromatic method shows national and landscape parks with their buffer zones, nature reserves and protected landscape areas. It is important to choose the right colours as this ensures proper distinguishability of individual areas (C.A. Brewer 2016). Other important elements are their hierarchy, allowing for the highlighting of the main forms of protection (parks, reserves), and shifting the less important (buffer zones) to the background.

The base content of the map (forests, rivers and lakes) makes it easy to see the characteristics of each protected area, e.g. whether it is related to the presence of valuable forest complexes or rivers and lakes.

Although protected landscape areas occupy large compact areas dominate in the Pod-

laskie Voivodship, this dominance has been visually reduced on the map by using of an appropriate pattern. The smallest areas occupied by nature reserves are shown with colour spots. In the southern part of the voivodship, there are relatively few areas under legal protection. Most of them are in the northern and south-eastern parts.

#### Area and symbols of national parks and landscape parks

The map at a scale of 1:1,500,000 shows the logos of Podlasie national and landscape parks (fig. 4). The symbols come from the official websites of the parks. Their size is proportional to the area of the parks they represent. In this way, the map user can easily see the relations between the parks' areas, and identify what is the main subject of protection. Such a combination of information and a graphic solution was hardly ever used in nature conservation maps.

#### National parks and landscape parks according to land cover

To present the category of land cover in parks, a structural bar diagram was used (fig. 5). The map at a scale of 1:1,500,000 shows the percentage share of each land category (forests, wooded and shrubby areas, arable lands, reserves, water, others) in the total area of parks. A simple structural chart was used, without taking into account the size of the parks' area (M. Zych, M. Pieniążek 2017), because it facilitates comparing the land structure between parks. The choice of colours refers to the colours used in the earlier map (fig. 3), to ensure the uniformity of the entire series.

The analysis of the map shows that in the parks located in the eastern part of the voivodship, forests are predominant, and in other parks the land classified as "other", with the exception of Suwałki Landscape Park located in the north, with a clear predominance of agricultural land.

#### "Natura 2000" areas

Figure 6 shows Birds Directive Sites (SPA) and Habitat Directive Sites (SAC) that are part of the European Ecological Network "Natura 2000". The chorochromatic method was used here, expressed graphically by patterns varied

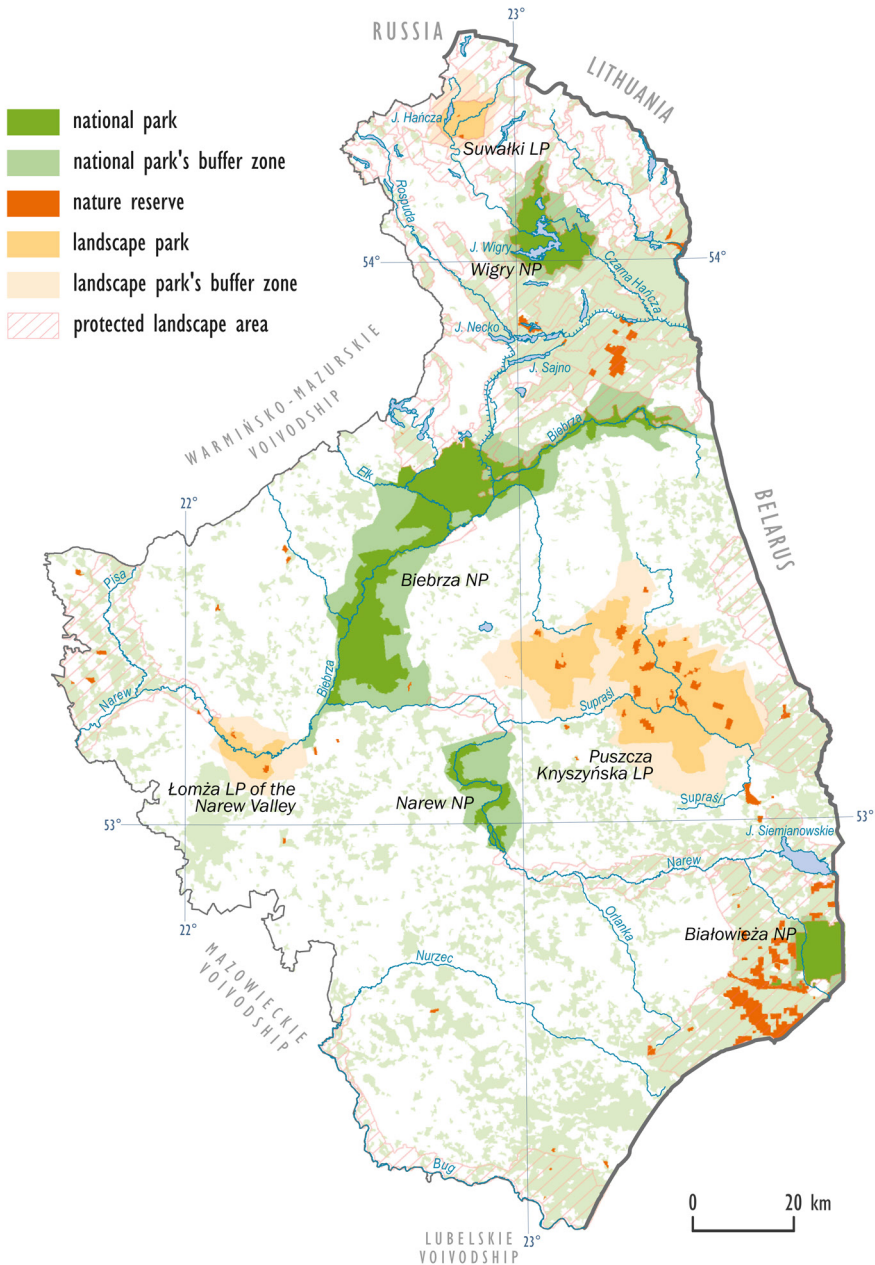


Fig. 3. Areas under legal protection

in colour, density, and direction. This makes it possible to easily distinguish the types of these areas and ensures a good visual relationship with the underlying content – forests and the water network.

**Legally protected area**

One of the most frequently used indicators concerning nature protection is the percentage share of the legally protected area in the area

the size of the symbol is proportional to the size of the park



Fig. 4. Area and symbols of national and landscape parks

of the entire enumeration unit – in figure 7, in the area of the commune. The choropleth map method was used, and the data was divided into six classes with different ranges, which

seems to be an optimal solution for the user (J. Paślowski 2003). The class limits have been placed in “gaps” in the statistical dataset so that data with similar values is included in one

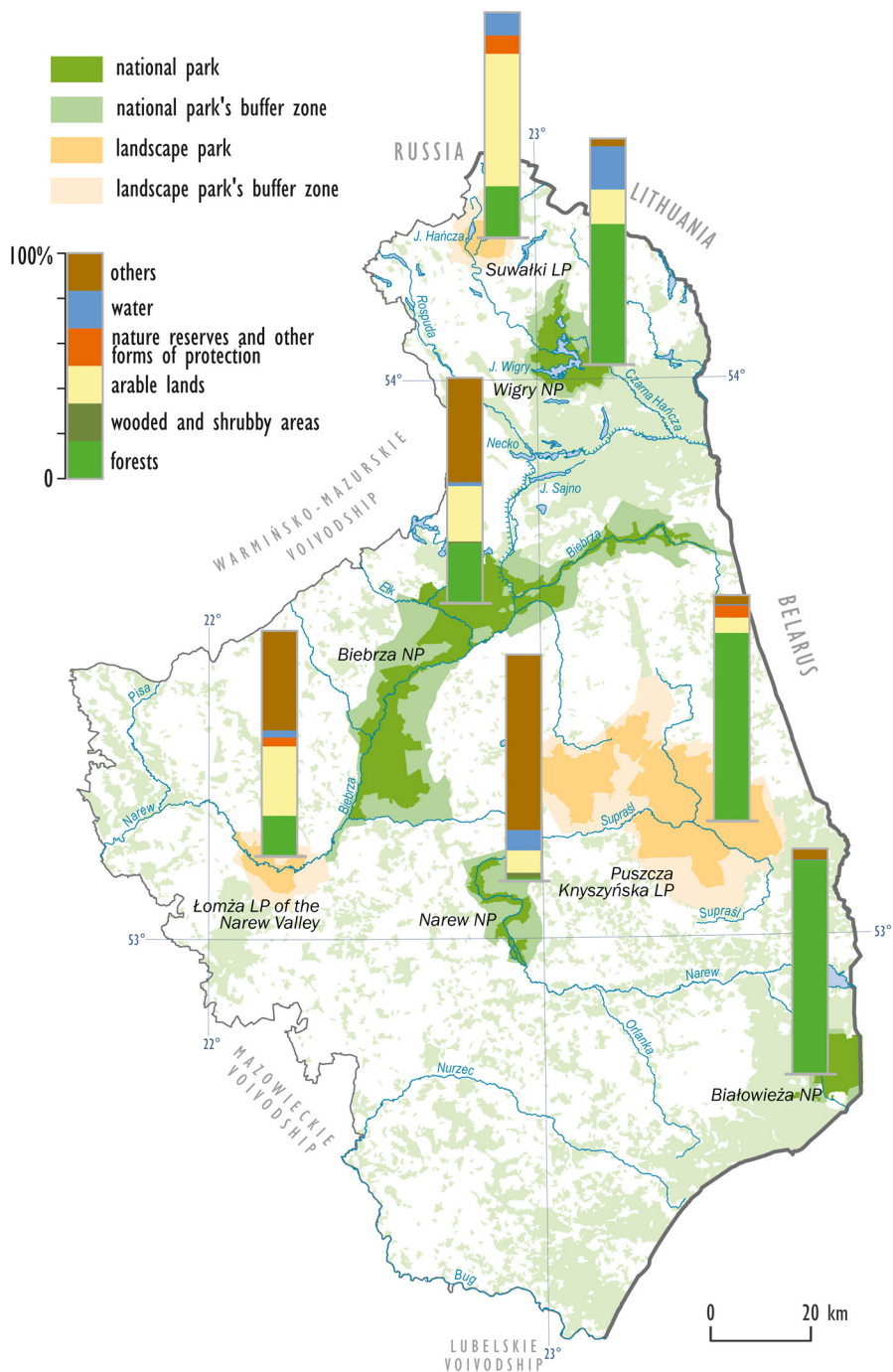


Fig. 5. National parks and landscape parks land cover



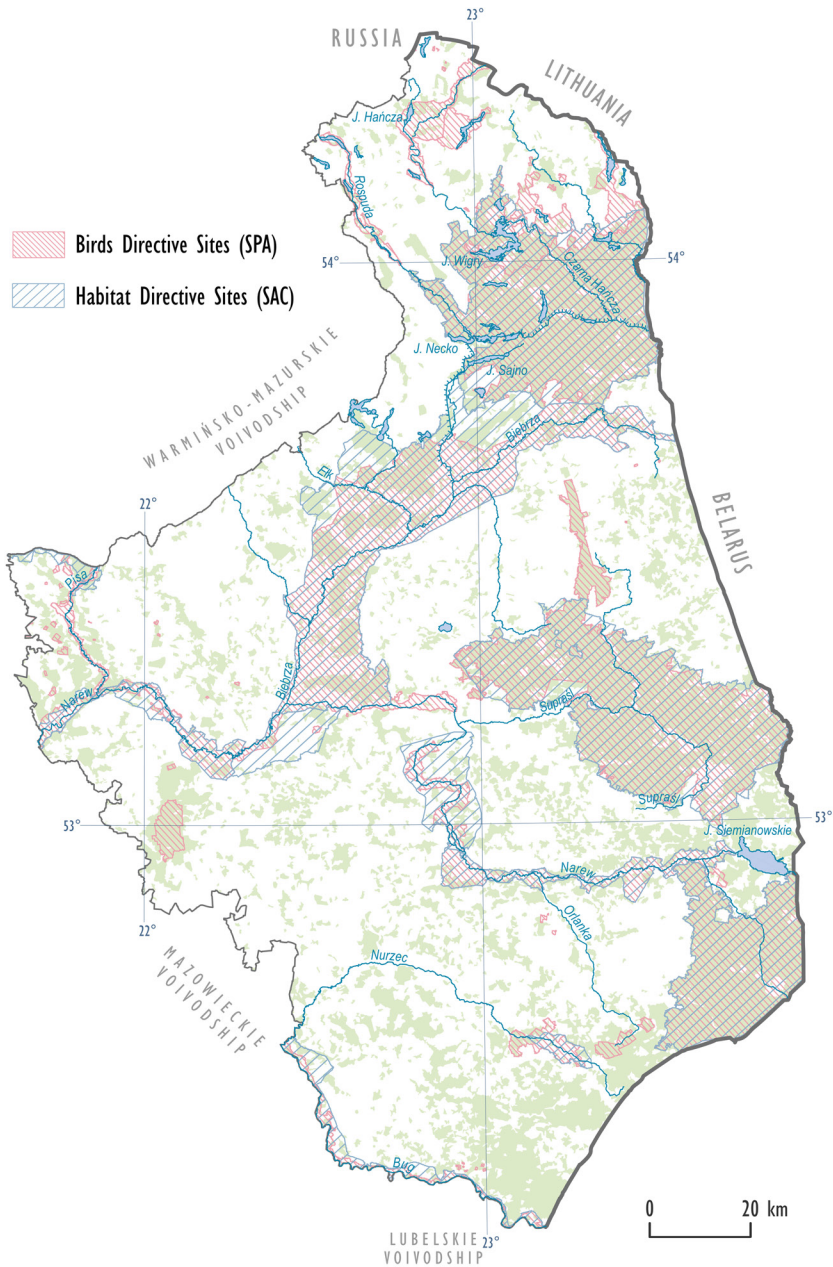


Fig. 6. "Natura 2000" areas

class. It was also ensured that the class limits had "round" values that were easy to remember. A one-hue colour scale was adopted in shades of green, i.e. in "natural" colours. Due to the statistical character of the map, it

was prepared at a scale of 1:2,500,000, i.e. smaller than the previous maps, because in the case of the choropleth method, the size of the reference field and the number of classes determine the level of detail, not the map scale.

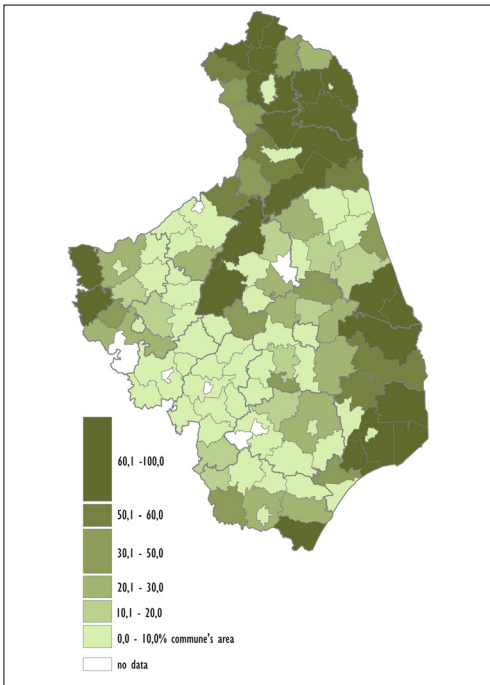


Fig. 7. Percentage of a legally protected area in communes

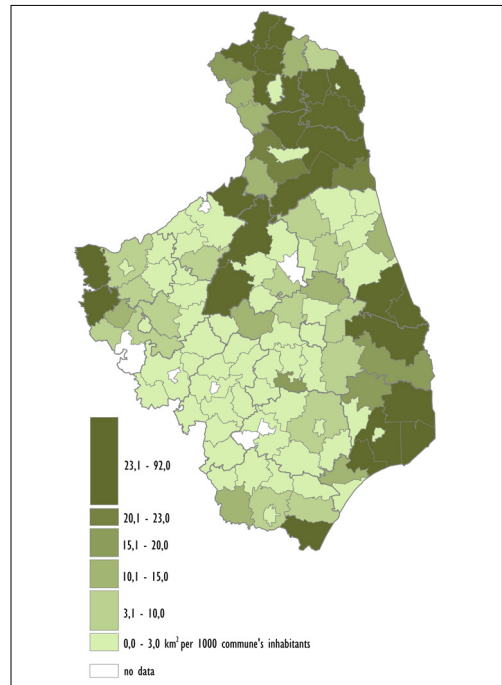


Fig. 8. The legally protected area per 1000 commune's inhabitants

For the purposes of the article, a choropleth map was also made based on higher-order units (powiats), but they turned out to be too large to properly show the spatial diversity of the issue.

Another presentation of a legally protected area is a comparison with the number of inhabitants, usually per 1000 inhabitants of a spatial unit, a commune in this case (fig. 8). Here, too, it turned out that the choropleth map based on powiats does not show significant spatial differentiation of the statistical indicator.

The analysis and comparison of the maps presented in figures 7 and 8 shows that the highest values of both indicators are found in the eastern and northern part of the Podlaskie Voivodship, i.e. where there are national and landscape parks.

The elaboration of maps showing the share of protected area in the area of communes (fig. 7) and in relation to their population size (fig. 8) allowed for reflection on the relationship between the area and population of the communes and its legal protection. Such relationships are pre-

sented in figure 9, where the horizontal axis is the area of communes (in  $\text{km}^2$ ), and the vertical axis is the share of the protected area (in %). Each commune is represented by a diagram whose size is proportional to the size of the population. The diagrams were additionally filled with colours: yellow – small communes (less than 10 thousand inhabitants), orange – medium (10–50 thousand inhabitants), red – large (over 50 thousand inhabitants). The summary of the data in the graph (fig. 9) and the use of redundancy (the size and colours of the diagrams show related information) allows us to see that the highest share of protected area is in areas with a relatively small population, and this in turn makes it possible to infer about human impact on the natural environment.

The statistical data of the Podlaskie Voivodship includes detailed information on the area occupied by individual forms of nature protection. In figure 10, this data is presented by means of a segmented diagram map, which shows the percentage share of forms of nature protection – national parks, nature reserves,

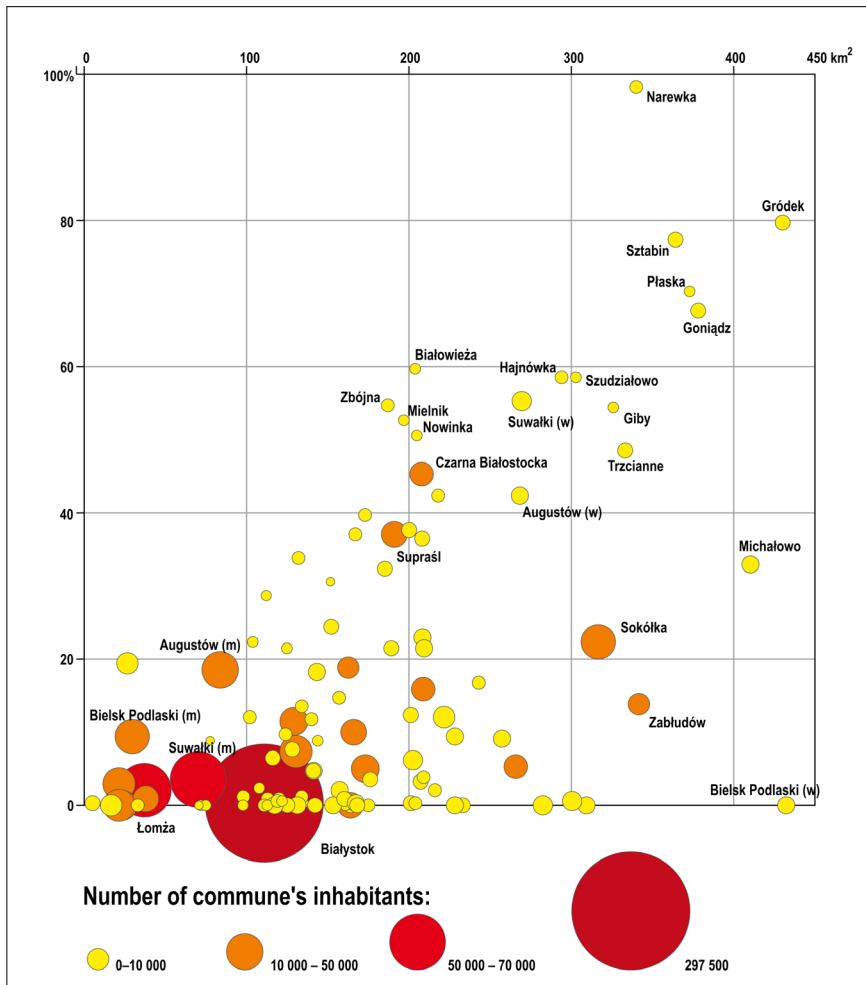


Fig. 9. The graph of legally protected area, commune's area and communes inhabitants

landscape parks, and protected landscape areas – in the legally protected area of individual powiats. It was decided that the weight of one segment (square) would correspond to 5% of the powiat area, but due to the low percentage of some forms of nature protection, the detail of the presentation was increased to 2.5% (half a square). For the sake of graphic uniformity, the map uses the same colours as in figure 3. The presentation of forms of nature protection in two perspectives – qualitative (natural) and quantitative (statistical) gives a broad, complementary picture of the phenomenon, especially its actual diversity.

### Natural monuments

Figure 11 illustrates natural monuments. Their number and types in relation to powiats have been presented using the summary-structural diagram method. The height of the diagrams changes proportionally to the number of monuments, which makes it easy to compare the values assigned to them, but makes it difficult to compare the structure of types of monuments. Nevertheless, it is easy to notice that in the entire region, animate nature monuments, especially individual trees, are the most frequent. In the northern part, in the area of the last gla-

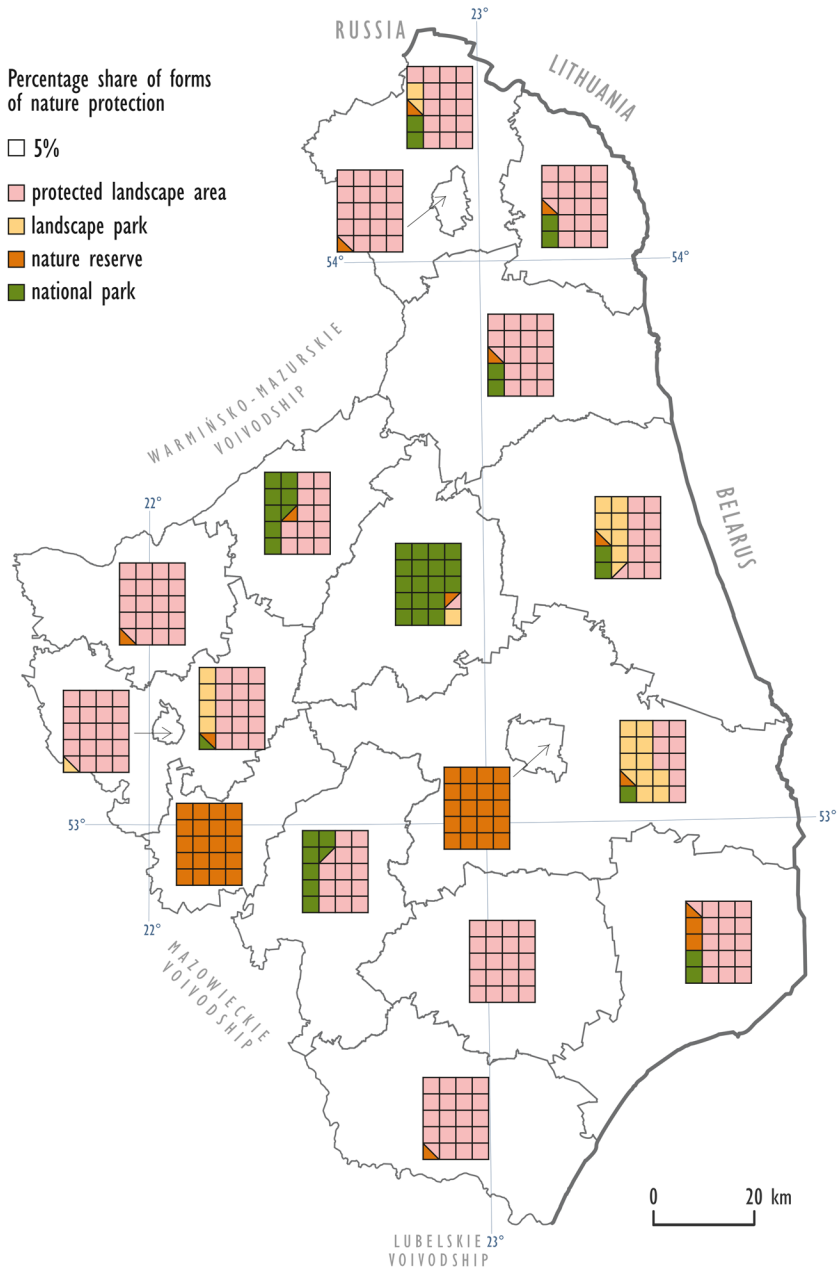


Fig. 10. The percentage share of forms of nature protection

ciation, there is a significant share of inanimate nature monuments in the form of erratic boulders.

The colours refer to those used on a map with a similar theme in the *Atlas of the Republic of Poland* [A2].

### Time of establishment the first forms of nature protection

Figure 12 shows information about the time when the first forms of nature protection were

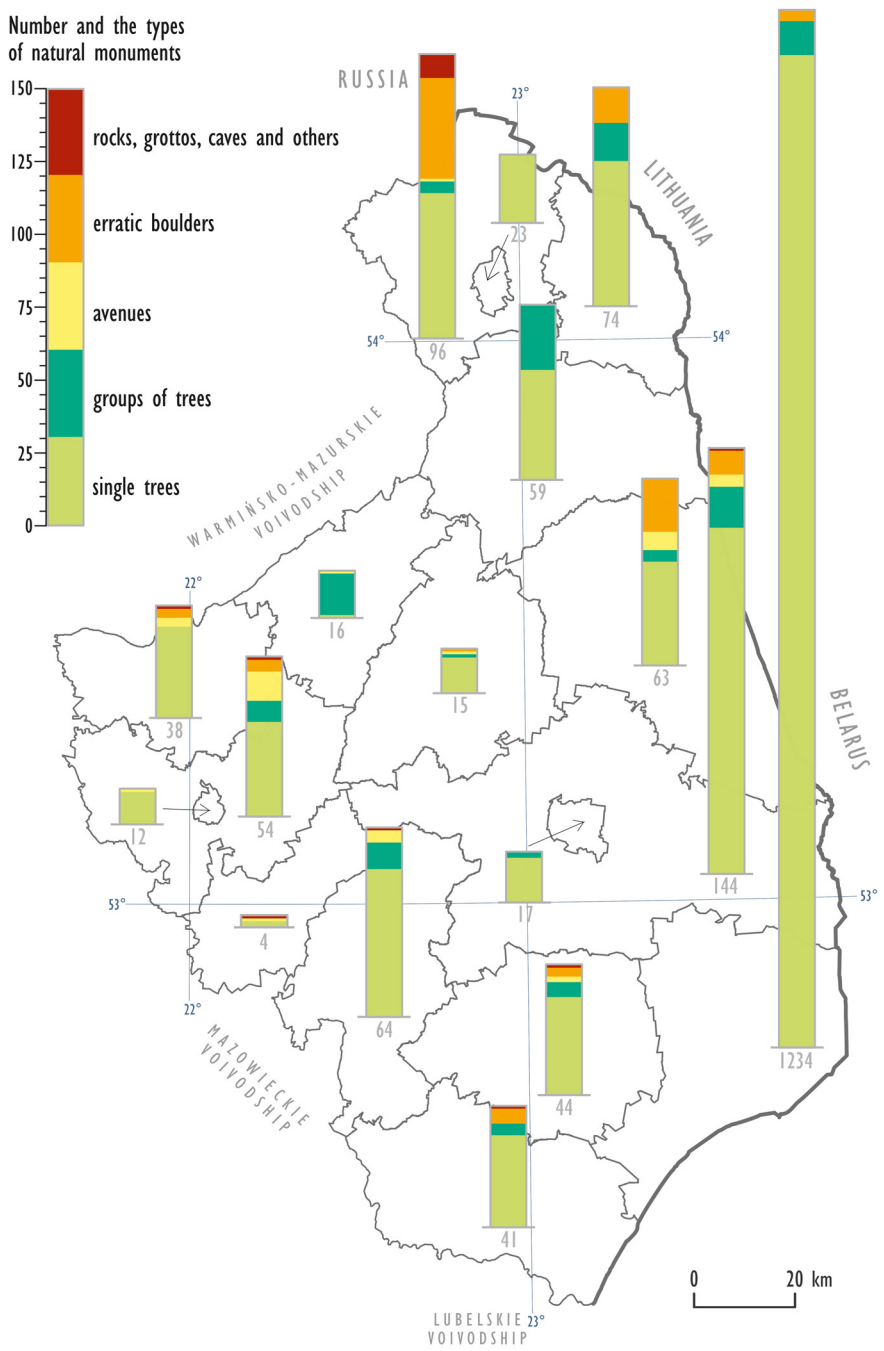


Fig. 11. Number and types of natural monuments

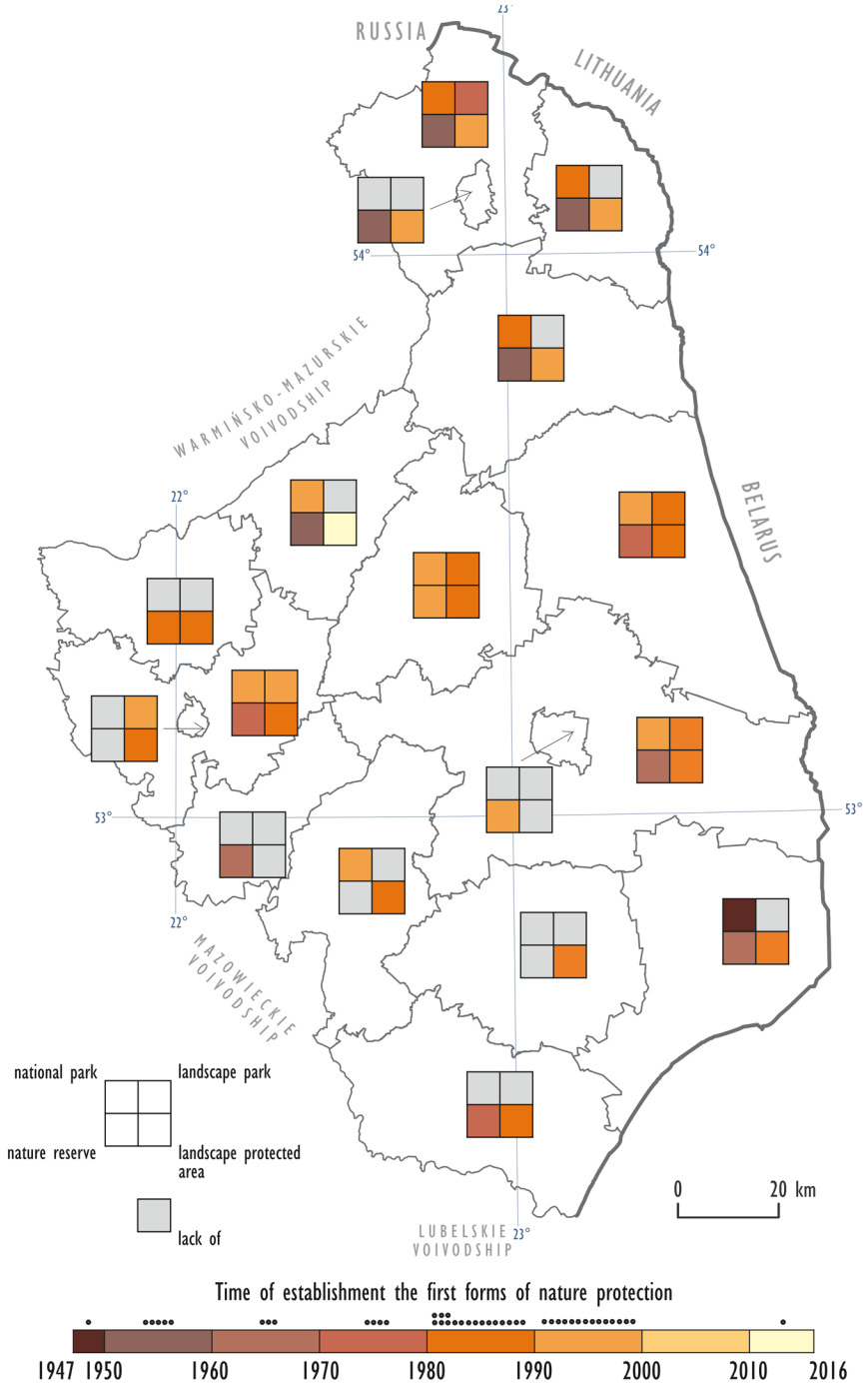


Fig. 12. Time of establishment the first forms of nature protection

established in each of the powiats. Dynamic signatures were used here, the coloured filling of which symbolises the time period in which a given form of nature protection was created. Brown is the oldest object, and yellow is the youngest, so a multi-hue sequential scheme was used here: the earlier, the darker. The beginning of the timeline is the year in which the oldest form of nature protection in the Podlaskie Voivodship was established and one of the oldest in Poland – the Białowieża National Park, established in 1947 (its beginning is assumed to be 1921, but formally this area has been functioning as a national park since 1947). At the end of the timeline is the year 2016 because this is the year from which the map compilation data comes. In addition, there are ‘dots’ above the timeline, each of which represents one form of conservation shown on the map. In this way, a histogram was created, thanks to which the map reader receives information about the number of the first forms of nature protection in ten-year time intervals. This method can be treated as a modification of the method proposed by K. Kałamucki and D. Buk (2010).

The map shows not only the spatial aspect of the formation of the first forms of nature protection in the voivodship, but also the time distribution of the decisions regarding their creation. It is clearly visible that the best period of activities for nature protection was the years 1980–2000, after which there was a regress that continues to this day.

## 6. Conclusions

The elaboration of maps is a process which requires both extensive substantive knowledge

related to their subject matter, but also editorial experience, especially in the field of cartographic methodology. The methodological solutions proposed in the article may be a good opportunity to analyse spatial data (Cz. Adamiak et al. 2019), to search for the most effective, from the point of view of the map user, graphic solutions (L. Havelkova, I. Gołębiowska 2020), as well as to check the possibilities of GIS tools used in cartography (S.Y. Han et al. 2018). The use of both GIS tools and graphic design software allowed for the presentation of natural phenomena using not only standard cartographic solutions, but also those less common, which will certainly interest map users, such as a logo in the form of diagrams, dynamic symbols, a graph of the relationship between the legally protected area and the population size, supplementing the content presented on statistical maps. Going beyond the standard cartographic visualisation framework, it has certainly contributed to the presentation of natural issues in a broader, more comprehensive context, which gives the user a more complete picture of the region's nature.

The Podlaskie Voivodship with its natural resources is an area which deserves to be looked at individually, not only in comparison to the whole of Poland. The series of maps proposed in the article illustrating the richness of these resources was prepared on the basis of generally available data. The maps are a collection characterised by methodological and graphic uniformity. The article is an attempt at a small-scale cartographic monograph that could be part of a larger whole, e.g. in the environmental atlas of this region.

## Literature

- Adamiak Cz., Szyda B., Dubownik A., García-Álvarez D., 2019, *Airbnb offer in Spain – spatial analysis of the pattern and determinants of its distribution*. “ISPRS International Journal of Geo-Information”, 8, 155, 26 pp.; DOI:10.3390/ijgi8030155.
- Brewer C.A., 2016, *Designing better maps: a guide for GIS users*. 2nd edition, Redlands, California: ESRI Press.
- Cebrykow P., 2017, *Elaboration of topographic bases for statistical maps, their contents and importance*. “Polish Cartographical Review” Vol. 49, 2017, no. 3, pp. 97–106; DOI: 10.1515/pcr-2017-0008.
- Dent B.D., Torguson J.S., Hodler T.W., 2009, *Cartography. Thematic map design*. 6th edition. New York: McGraw-Hill Higher Education.
- Drabik L., Sobol E. (eds.), 2007, *Słownik języka polskiego PWN*. Tom 2: P–Ż, Warszawa: Wydawnictwo Naukowe PWN.
- Fabijańska P., Korycka-Skorupa J., 2018, *A thematic cartographic visualization of a small region, based*

- on the example of the Mrozy Commune. "Miscellanea Geographica" Vol. 22, no. 3, pp. 150–156; DOI: 10.2478/mgrsd-2018-0008.
- Gołębiowska I., 2015, *Legend layouts for thematic maps: a case study integrating usability metrics with think aloud method*. "The Cartographic Journal" Vol. 52, no. 1, pp. 28–40; DOI: 10.1179/1743277413Y.0000000045.
- Han S.Y., Rey S., Knaap E., Kang W., Wolf L., 2019, *Adaptive choropleth mapper: an open-source web-based tool for synchronous exploration of multiple variables at multiple spatial extents*. ISPRS International Journal of Geo-Information", 8, 509, 20 pp.; DOI:10.3390/ijgi8110509.
- Havelková L., Gołębiowska I., 2019, *What went wrong for bad solvers during thematic map analysis? Lessons learned from an eye-tracking study*. "ISPRS International Journal of Geo-Information" 9, 9, 27 pp.; DOI:10.3390/ijgi90100098.
- Hernshaw H.M., Unwin D.J., 1994, *Visualization in geographical information systems*. London: Viley.
- Jovanović J., 2012, *Cartographic visualization and information society*. "Geografski Razgledi" 46, pp. 59–68.
- Kalamucki K., Buk D., 2010, *Metodyczne aspekty badania i prezentacji na mapach zmian zjawisk na przykładzie infrastruktury turystycznej Roztoczańskiego Parku Narodowego*. „Polski Przegląd Kartograficzny” T. 43, nr 3, pp. 199–210.
- Korycka-Skorupa J., 2002, *Od danych do mapy. Część I*. "Polski Przegląd Kartograficzny" T. 34, nr 2, pp. 91–102.
- Korycka-Skorupa J., 2015, *Effectiveness of cartographic presentation methods applied within small-scale thematic maps in the press and on the Internet*. "Polish Cartographical Review" Vol. 47, no. 1, pp. 5–7.
- Kraak M.-J., Ormeling F., 1996, *Cartography: visualization of spatial data*. London: Addison Wesley Longman Limited.
- McEachren A.M., Taylor D.R.F., 1994, *Visualization in modern cartography*. "Modern cartography series". Oxford: Pergamon.
- Medyńska-Gulij B., 2011, *Kartografia i geowizualizacja*. Wydawnictwo Naukowe PWN, Warszawa.
- Medolińska K., Gołębiowska I., Karsznia I., 2018, *Local GIS: development and assessment of the geoportal for local governments and local communities. Case study of a small town in Poland*. "Miscellanea Geographica" Vol. 21, no. 4, pp. 160–167; DOI: 10.1515/mgrsd-2017-0031.
- Pasławski J., 2003, *Jak opracować kartogram*. Warszawa: Uniwersytet Warszawski, Wydział Geografii i Studiów Regionalnych.
- Raport o stanie środowiska województwa podlaskiego 2015*; [http://www.wios.bialystok.pl/pdf/wios\\_raport2015\\_wersja\\_WWW.pdf](http://www.wios.bialystok.pl/pdf/wios_raport2015_wersja_WWW.pdf) (access 11.05.2020).
- Slocum T.A., McMaster R.B., Kessler F.C., Howard H.H., 2005, *Thematic cartography and geographic visualization*. 2nd edition. Upper Saddle River, NJ: Pearson Prentice Hall.
- Statistical Office in Białystok, 2017a, *Ochrona środowiska i leśnictwo w województwie podlaskim w 2016 r.*, „Informacje i opracowania statystyczne” Rok XIII, Białystok, Rozdział VI.
- Statistical Office in Białystok, 2017b, *Województwo podlaskie – podregiony, powiaty, gminy*, Białystok, Rozdział IV.
- Ustawa z dnia 16 kwietnia 2004 r. o ochronie przyrody*. „Dziennik Ustaw RP” 2004, Nr 92, poz. 880.
- Voženilek V., Kaňok J., 2011, *Metody tematické kartografie*. Olomouc: Univerzita Palackého v Olomouci.
- Zych M., Medolińska K., 2018, *New statistical atlases of voivodships and Poland*. "Polish Cartographical Review" Vol. 50, 2018, no. 4, pp. 183–196; DOI: 10.2478/pcr-2018-0014.
- Zych M., Pieniążek M., 2017, *Mapy statystyczne. Opracowanie i prezentacja danych*. Warszawa: Główny Urząd Statystyczny.

### Atlases

- [A1] *Narodowy Atlas Polski*. Polska Akademia Nauk, Instytut Geografii, Zakład Narodowy imienia Ossolińskich, Wrocław 1973–1978.
- [A2] *Atlas Rzeczypospolitej Polskiej*. Główny Geodeta Kraju, PAN, Instytut Geografii i Przestrzennego Zagospodarowania, Warszawa 1993–1998.
- [A3] *Atlas zasobów, walorów i zagrożeń środowiska geograficznego*. Polska Akademia Nauk, Instytut Geografii i Przestrzennego Zagospodarowania, Warszawa 1994.
- [A4] *Atlas województwa białostockiego*. Instytut Geografii Polskiej Akademii Nauk, Prezydium Wojewódzkiej Rady Narodowej w Białymstoku, Wydawnictwa Geologiczne, Warszawa 1968.
- [A5] *Atlas statystyczny województwa podlaskiego*. Urząd Statystyczny w Białymstoku. Białystok 2018.
- [A6] *Szkolny atlas geograficzny*, Demart S.A., Warszawa 2014.
- [A7] *Szkolny atlas Polski*, Demart S.A., Warszawa 2017.