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## PHYSICO-GEOGRAPHICAL MESOREGIONS OF POLAND: VERIFICATION AND ADJUSTMENT OF BOUNDARIES ON THE BASIS OF CONTEMPORARY SPATIAL DATA

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## Abstract

The programme of identification, cataloguing and evaluation of Polish landscapes, part of the implementation of the European Landscape Convention, has caused an increase in interest in physico-geographical regionalisation over recent years. The commonly accepted regionalisation of Poland developed by J. Kondracki (Kondracki & Richling 1994) is sufficient for work at an overview scale (e.g. 1:500,000), whereas its spatial accuracy is too low to make use of it for the purpose of Polish landscape cataloguing. The aim of this article is to present a more up-to-date and detailed division of Poland into mesoregions, adjusted to the 1:50,000 scale. In comparison with older work, the number of mesoregions has increased from 316 to 344. In many cases, some far-reaching changes in meso- and macroregions were made. Nevertheless, in most cases the previous system of units was maintained, with more detailed adjustment of boundaries based on the latest geological and geomorphological data and the use of GIS tools for the DEM analysis. The division presented here is a creatively developing new work aligning the proposals of the majority of Polish researchers. At the same time, it is a regionalisation maintaining the idea of the work developed by J. Kondracki as well as his theoretical assumptions and the criteria used to distinguish units, which makes it a logical continuation of his regional division.

## Key words

regionalisation • spatial units • boundaries of regions • Poland

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## Introduction

Legal regulations introduced in 2015<sup>1</sup> introduced the obligation to carry out a so-called landscape audit, i.e. a periodical comprehensive review and assessment of the state of the Polish landscape. In turn, it created the necessity to develop a commonly accepted methodology of delimitation, typology and valuation of current landscapes. This task had a direct impact on the increasing interest in physico-geographical regionalisation due to the proposed audit methodology. The landscapes that are distinguished should be established and described in the context of different types of geographical regional units (Solon et al. 2015). In the course of further work, it appeared that only the physico-geographical regionalisation (Kondracki & Richling 1994), which covers the entire

territory of Poland, is commonly accepted and sufficient for work at an overview scale (e.g. 1:500,000). However, its spatial accuracy is definitely too low for it to be used directly for the landscape audit.

The first unpublished attempts to specify the boundaries of physico-geographical mesoregions as basic units in the above mentioned regionalisation were made in 2015-2016 in the Institute of Geography and Spatial Organisation of Polish Academy of Sciences, and then in the Institute of Environmental Protection – National Research Institute. This experience gave rise to the idea of establishing a team of specialists from different research centres for joint verification and adjustment of the physico-geographical division of Poland.

It is worth emphasizing that more than 20 years have passed since the development of the previous comprehensive version of a regionalisation. Since then numerous new details have been obtained concerning the diversity of the components of the natural environment in Poland and very powerful instruments have become available for the analysis of spatial diversity in GIS systems.

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<sup>1</sup> The Act of 24 April 2015 amending certain acts in relation to strengthening tools of landscape protection instruments (Journal of Laws of 2015, item 774). The Act amended the Nature Protection Act of 16 April 2004 (Journal of Laws of 2016, item 2134, as amended) and the Spatial Planning and Management Act of 27 March 2003 (Journal of Laws of 2017, item 1073, as amended).

Moreover, over the last 15-20 years many Polish academic centres have developed different new proposals for regional divisions of small areas performed by means of various techniques and methodologies.

The significance of the problem became apparent at a joint conference of the Cultural Landscape Commission of the Polish Geographical Society and the Polish Association for Landscape Ecology held in May 2017: *New Challenges to the Regionalisation of Poland*. The aim of this conference was to discuss the need for the verification of previous regional divisions, the presentation of concepts and methodology (sources, materials, criteria) as well as the presentation of specific proposals for regionalisation and solutions. An equally important aim was to indicate the current opportunities for the practical use of the regionalisation procedure and their effects on the preparation of landscape audits (Nita et al. 2017).

The aim of this article is to present a more up-to-date and detailed division of Poland into mesoregions, adjusted to the 1:50,000 scale. The division presented is not a simple compilation of previously published proposals, but it is a creatively developing new work aligning the proposals of most Polish researchers dealing with this problematic issue. At the same time, it is a regionalisation maintaining the idea and spirit of regionalisations developed by J. Kondracki as well as his theoretical assumptions and the criteria he used to distinguish units, which makes it a logical continuation of his work.

## **History and evolution of the physico-geographical division of Poland developed by Professor Jerzy Kondracki**

In the "Physical Geography of Poland" written by S. Lencewicz (1955), which was to a great extent a reprint of the "Great Universal Geography" (Lencewicz 1937), J. Kondracki introduced numerous additions and adjustments taking account of the changed boundaries of Poland after the Second World War. In particular,

he included a description of large geographical regions (Coastal Lowlands, Pomeranian Lakeland, Masurian Lakeland, Wielkopolska-Kujawy Lowland, Masovia-Podlasie Lowland, Lublin Upland, Kielce-Sandomierz Upland, Nida Basin, Kraków-Częstochowa Upland, Silesian Upland, Silesian Basin and Trzebnica Hills, Sudety Mts and Sudety Foothills, Sub-Carpathian Basins, Flysch Carpathians, Tatras and Podhale), following the concepts and layout of Lencewicz's original handbook. At the same time, the large regional units distinguished referred to the results of the discussion taking place from 1946-1947 at conferences organised by the Polish Geographical Society (Kondracki 1946a, 1946b), although they were not identical both in terms of nomenclature and the hierarchical rank of units.

The same year, J. Kondracki (1955) published an article in which he not only presented criteria used to distinguish regions and rules for their nomenclature, but also undertook a discussion with other authors for their views. More importantly, he presented his own original scheme for the regional subdivision of Poland. He took into account 6 very large units, 16 regions and 80 subregions.

Further development of work on the regionalisation of Poland resulted in the presentation by Kondracki (1961) of a terminological scheme of hierarchical regional units and the identification of 7 physico-geographical provinces (comprising 14 subprovinces) on the territory of Poland, included in 2 large areas. This division (together with the proposed names of the units which were mainly new) has been applied until now with no substantial changes. In addition, this article listed 39 macroregions and 210 smaller units (most frequently corresponding to mesoregions within the current approach). Unfortunately, the work does not include a map illustrating the boundaries of the units that were distinguished.

This division, with minimal modifications in the number of units (6 provinces, 14 subprovinces, 39 macroregions, 212 mesoregions) and the original letter and digit coding

system, was applied in two editions of the "Physical Geography of Poland" (Kondracki 1965a, 1967).

Further evolution of the physico-geographical division of Poland resulted in the introduction of a uniform digit coding of regional units (Kondracki 1965b). In the work cited, J. Kondracki included all the subprovinces and macroregions listed in the work from 1961, assigning them uniform decimal codes following the system put forward one year earlier by the International Geographical Union.

This stage of regionalisation was summarised in a work from 1968 (Kondracki 1968). It listed 364 mesoregions, a proportion of which were outside Poland. A map attached to the article (developed by J. Kondracki and J. Ostrowski) showed the boundaries of mesoregions which became a standard for many years. This work also contributed to the standardisation of names and their common use. It was also included at 1:2,000,000 scale in the National Atlas of Poland (Kondracki & Ostrowski 1973-1978).

A map with different graphics but with generally the same boundaries was included in the "Physico-Geographical Regions of Poland" (Kondracki 1977). It included 6 provinces, 18 subprovinces, 56 macroregions and 318 mesoregions. It differs from the previous map by the use of changed numbering in relation to some of the mesoregions as well as by several small additions and amendments. An identical layout of regional units was also included in later editions of the "Physical Geography of Poland" (e.g. Kondracki 1978, 1988).

In 1994, two important cartographic developments were published. The first one was a map entitled "Types of natural landscape and physico-geographical units" by J. Kondracki and J. Ostrowski, constituting an appendix to the book (Kondracki 1994). In the table of contents of the map, there are 309 mesoregions, while the boundaries of the units differ in many places from the boundaries on the map of 1977. The differences result not only from a different

precision of drawings, but also from substantial changes which have been intentionally introduced.

The second map is a presentation of the physico-geographical regions in the Atlas of the Republic of Poland (Kondracki & Richling 1994). It is based on the map from 1977, but the boundaries are clearly modified. The previous general drawing was just made more detailed, whereas the regions were substantially changed (based on substantive criteria). It should be noted that these changes differ from the modifications introduced in the map developed by J. Kondracki and J. Ostrowski in 1994.

The map from the Atlas of the Republic of Poland became a new standard and was reproduced many times, for example in the "Regional Geography of Poland" (Kondracki 1998, 2000).

Kondracki (2000) stated that the maps published in the Atlas of the Republic of Poland, together with the standardisation and official approval of the names of the regions, completed the last stage in the development of views on the physico-geographical regionalisation of Poland. Nevertheless, this statement should not be treated as an arbitrary proposal to refrain from further work on regionalisation, in particular in relation to issues concerning the boundaries of the mesoregions, which mainly intervene at a more detailed spatial scale. The necessity to perform this work is also confirmed by the fact that numerous maps included in the compilation from 2000 (Kondracki 2000) reflect the boundaries not only at a different level of cartographic detail (in comparison with the Atlas of the Republic of Poland) but also with different substantive drawings, frequently differing to a great extent from the boundaries included in all earlier versions of the map.

### **Selected examples of regional physico-geographical division**

In parallel with later versions of Polish regionalisation developed by J. Kondracki, work

on regionalisation was performed in different academic centres. Part of this simply concerned local issues, other work of a regional nature covered individual provinces (voivodships) or large morphological units. These publications, occurring at a different frequency in various centres and periods of time, were sometimes polemical in relation to the solutions proposed by J. Kondracki, but they often concerned only proposals for more detailed delineation of the boundaries. Most of the works published by the mid-1980s are only of historical value, whereas later works had a clear impact on contemporary views on physico-geographical regionalisation. It is particularly clear in relation to the southern part of the country.

In Poland, physico-geographical regionalisation of the Carpathians was generally only carried out by authors from the Kraków centre, while everybody indicated the need for modification of the division made by J. Kondracki, in particular for areas of the former Kraków Voivodship (Czeppe & German 1979), the area of the Carpathian Foothills (German 1992), and the whole area of the Polish Carpathians together with the Eastern Carpathians (Balon et al. 1995) and the Małopolskie Voivodship (German 2001). Differences between different approaches were analysed, for example, by W. Maciejowski (2009). In the works of J. Balon and M. Jodłowski (Balon & Jodłowski 2005; Jodłowski & Balon 2005), the authors analysed existing divisions and proposed further changes in the Polish-Slovak border area. In accordance with the principle of political neutrality of physico-geographical regions (Balon 2000), some corrections were made in regional boundaries and taxonomic categories, and the modification of names was proposed; the changes were aimed at achieving greater consistency between Polish regionalisation and the Slovak divisions. These works resulted, for example, in the regionalisation of the Małopolskie Voivodship (Balon et al. 2012). The above mentioned divisions of the Carpathians were defined at the overview scale. The attempt to analyse them at a more detailed scale revealed inaccuracies

and errors, including areas not belonging to any of the regions distinguished or of environmental features that are completely different from the characteristics of the regions to which they had been assigned. The attempt to solve several similar problems with the regionalisation of the central part of the Western Carpathians was presented in the work of J. Balon (2012). Much attention was paid to the boundaries of the Tatra Mts (Balon 2001; Balon et al. 2015a, 2015b; Jodłowski 2001, 2002) and the Kraków Gate (Balon & German 2007). The cross-border regionalisation of the Western Carpathians is included in the work of J. Balon and M. Jodłowski (2014).

An example of the Authors' approach to the larger area is the physico-geographical regionalisation of the Podkarpackie Voivodship (Ziaja 2009), based on the scope of the higher units in the work of J. Kondracki (1998), but introducing numerous corrections at the level of mesoregions. These corrections resulted from the Authors' own research studies and used the results of such earlier works as the work of J. Balon et al. (1995) referring to the Carpathians or the work of J. Buraczyński (1997) concerning the Roztocze macroregion and the publications of P. Wład (1996a, 1996b) discussing the former Przemysł Voivodship.

The issues of the physico-geographical regionalisation of border regions of the south-western Poland lowlands, mountains and uplands were explored at Opole University. The studies concerned mainly the Głubczyce Plateau (Badora 2007) and the Opole Hummock (Badora 2016). In the first case, it was proposed to exclude the Głubczyce Plateau from the Silesian Lowland and to include it into the Sudety Foreland. This was suggested by J. Kondracki (2000), who indicated that this unit has upland features and belongs to the Sudety Foreland. Moreover, taking into account the diversity of geological structure and terrain relief, it was proposed to divide this mesoregion into a western part called the Nysa Kłodzka and Osobłoga Interfluve by L. Baraniecki (1968) and an eastern part

called the Głubczyce plateau by A. Jahn (1968). The studies of the physico-geographical allocation of the Upper Cretaceous Opole Hummock resulted in two alternative solutions being proposed: the inclusion of this previously unclassified unit, together with the gorge section of the valley of the Oder River between Opole and Krapkowice, into the Silesian Upland or its separation within the Silesian Lowland as a new upland mesoregion (Badora 2016).

Regional divisions of the Silesian-Kraków Upland, including the divisions of administrative units located within its boundaries, e.g. the division of the area of what was, until 1999, the Katowice Voivodship, and then later the Silesian Voivodship, and even of units at the level of a commune, were the subject of the work of different authors, part of which was developed in the University of Silesia. They were usually proposals for detailed subdivisions of mesoregions and took into account features of the abiotic environment at a local level (Szaflarski 1955; Karaś-Brzozowska 1960; Czeppe 1972; Nita 2008; Dulias 2013; Myga-Piątek & Nita 2013). The creation of these subdivisions consisted in distinguishing physico-geographical units at the level of microregions, and even submicroregions. These detailed subdivisions revealed non-compliance with the boundaries of the mesoregions developed by J. Kondracki. In some cases, differences concerned only the details of the work carried out and the cartographic scale at which it was performed (Szaflarski 1955; Karaś-Brzozowska 1960; Czeppe 1972; Nita 2008, 2010).

Examples of such work are included in the published proposals for the subdivision into geographical units, e.g.: the Częstochowa Upland (Czeppe 1972), the Silesian Upland (Szaflarski 1955; Karaś-Brzozowska 1960; Dulias & Hibszer 2004; Dulias 2013), Woźniki Rock Step (Nita J. & Nita M. 2014), or administrative units e.g. Będzin Commune (Pulina et al. 2008). Generally, the issue of regionalisation was not the main purpose of the works cited herein, but in most cases it was a side-issue raised in addition to the main

topic of the work (e.g. the analysis of the geological structure and detailed relief). The issue of regional divisions was even more rarely raised in relation to higher hierarchical levels – macroregions (Nita 2010) or subprovinces (Nita 2013), where the author proposed boundaries of the Polish Uplands different from the division made by J. Kondracki.

A new division into mesoregions and units of a lower rank has recently been proposed for the Silesian Upland (Nita et al. 2016). For the Silesia-Kraków Upland, the geomorphological division developed by S. Gilewska (1972, 1986), reflecting particularly well the physico-geographical units, was established in literature and is frequently applied as a starting material. Nevertheless, the simultaneous application of the division at both scales causes spatial and terminological chaos.

At the beginning of the 21st century, the Silesian centre, like other centres, developed work designed to provide a greater specification of the boundaries of the physico-geographical regions with the use of a Digital Terrain Model (Nita 2002, 2010). The availability and accuracy of the Digital Terrain Model revealed the technical potential to perform a greater specification and verification of the existing divisions (Myga-Piątek & Nita 2013; Nita et al. 2016). These works also drew attention to important methodological assumptions useful in the bottom-up procedure applied in order to verify the boundaries of meso- and macroregions (Nita et al. 2016), as well as to the consequences and dangers of methodological errors in generalised divisions while moving to units of a lower rank.

The proposals for the regional subdivision of the Sudety Mts and other areas of southwestern Poland were presented by P. Migoń from the Wrocław University (Migoń 2005; Migoń & Kasprzak 2015), who paid a great deal of attention within his approach to the geological and tectonic diversity of the terrain in particular. His proposal partially refers to other work developed in this centre which repeatedly indicated the non-compliance of the Czech and Polish regional divisions in the border zone of the Sudety Mts. At the

same time, the standardisation of the regional division and changes in the boundaries and nomenclature of mesoregions were proposed (Potocki 1994, 2000; Łach et al. 2010; Rozenkiewicz & Łach 2012).

Thorough regionalisation studies were less frequently carried out in relation to the central part of Poland, which may result from the fuzziness and less distinct physico-geographical boundaries of terrain composed of old glacial relief.

The area of the current Świętokrzyskie Province (Voivodeship), the central part of which is constituted by the Świętokrzyskie Mountains, has never been subject to any complex regionalisation study, and is considering newer approaches to the diversification of the abiotic environment. Although this area was of interest to researchers from many scientific centres, most of their studies – excluding the studies conducted by R. Czarnecki (Balwirczak-Jakubowska & Czarnecki 1989; Czarnecki 2005) from the Warsaw University – were of a contributory and secondary character.

More interesting research studies only started to come into sight at the end of the 20th century, i.e. from the scientific centre in Kielce (now The Jan Kochanowski University in Kielce, which is the successor of the pre-existing pedagogical universities in this city). They showed, among other things, the need to change the boundaries of the mesoregion of the Świętokrzyskie Mountains (Kowalski 1993; Mityk 1993) which were associated with the concepts for distinguishing and characterising microregions (Dziedzic B. & Dziedzic P. 1990; Kowalski 1993; Strzyż 2017). The distinct field of research work was applied to utilitarian issues, in which the scholars focused mostly on landscape and typology issues, and the regionalisation approaches were only of a supportive character (Mityk 1993; Strzyż 2014). In this perspective, special attention should be drawn to the research studies of J. Mityk (1983a,b, 1993) with regard to the regional typology of the Kielce area, which includes a detailed methodology of delimiting the boundaries

of microregions. The author employed the method of delimitation of geocomplexes combined with multivariate analysis.

Among the work conducted at the University of Łódź special attention should be paid to the monograph covering the 8 voivodships which existed at that time in central Poland in which the literature concerning regional divisions and geographical nomenclature of physico-geographical units was reviewed (Papińska 1993). The work of G. Bezkowska (1998) in which the spatial scope was limited to 5 mesoregions of central Poland (Koło Basin, Sieradz Basin, Szczerców Basin, Kłodawa Heights and Łask Heights) was published a little later. The biggest disadvantage of this article is the lack of maps presenting descriptions of the results of the studies carried out by the author, although the 69 microregions distinguished undoubtedly contributed to the change of the boundaries of the mesoregion. One year later, G. Bezkowska (1999) presented the concept of distinguishing a regional unit of macroregion rank, called the Łódź region by the author. She indicated its individual character and the possibility of distinguishing its boundaries in a relatively easy way. The latest initiatives undertaken in the Łódź centre concern issues of physico-geographical microregionalisation, whose “side” effect is a proposal to change the boundaries of the mesoregion (Majchrowska & Papińska 2018).

The most important regional divisions in the eastern part of the Polish uplands together with surrounding areas were developed in the 1950s in the geographical unit associated with the Maria Curie-Skłodowska University in Lublin. Different criteria were adopted in order to distinguish units and to establish their boundaries and nomenclature. One of the first original concepts of how to do this was the work of A. Chatubińska and T. Wilgat (1954), in which the regionalisation was based on the diversity of geological structure, hypsometry, relief, hydrography, climate, soil and vegetation. Within a short time, A. Jahn (1956) had published a morphological division of the Lublin Upland.

The division was based on cartographic materials and field observations. Another important development was the work of H. Maruszczak (1972) published much later, in which the author proposed the division of the Lublin uplands into four geomorphological macroregions: Roztocze, the Pobuże Basin, the Lublin Upland and the Volhyn Upland which was then further divided into 17 mesoregions. This regionalisation in terms of nomenclature and boundaries referred to the regionalisation of A. Chałubińska and T. Wilgat (1954) and A. Jahn (1954, 1956). The division was based on two main criteria – features of the terrain relief and the geological structure. After the work of Maruszczak, there was a 20-year period of stagnation. During these years, different authors just repeated earlier proposals and used them as the basis for different thematic regionalisations. Original new work on regionalisation dedicated to Roztocze was only published in 1995 (Buraczyński 1995). The division of Roztocze was based on features of the terrain relief and the geological structure. The following features of the terrain relief were of significant importance: hypsometric gradients and elements of the relief connected with the diversity of surface sediments and exposures of bedrocks. The following features of geological structure were crucial: the origin-linked relationship of the boundaries with faults of different rank and the role of erosion, denudation and accumulation processes in shaping the landscape features.

At the University of Warsaw, in addition to the above mentioned work of J. Kondracki and his research partners covering the entire territory of Poland and ongoing work on their improvement, numerous theoretical and methodological works were published which set down the rules for the regionalisation and typology of spatial units of different rank written by A. Richling, R. Czarnecki, K. Ostaszewska and W. Lewandowski.

Research on the structure of the natural environment in the vicinity of Płock should be particularly emphasised among the regional works. One of the more important

studies is the physico-geographical regionalisation of the former Płock Voivodship at a 1:100,000 scale (Richling & Czajkowski 1988). This involved greater specification of the boundaries of the subprovinces, macro- and mesoregions, whereas the delimitation of microregions was performed with the use of a method which consisted in combining typological geocomplexes into larger units. Later, the immediate vicinity of Płock was analysed in detail in terms of regional boundaries. A great deal of these research studies involved the verification of the mesoregion boundaries and their adjustment to detailed scales (including the 1:10,000, 1:50,000 and 1:100,000 scales) and the delimitation within the existing regional division of units of lower rank – microregions and submicroregions – with the use of inductive and deductive methods. The degree of modification of mesoregion boundaries was mainly conditioned by the amount of detail in the input data concerning individual components which constitute the basis for the delimitation of the individual hierarchical levels of the regional division, but also their consistent application. Bottom-up methods of regionalisation resulted in significant movements of the boundaries of individual higher (above microregion) levels of the regional division, especially when the boundaries of sub- and microregional units were consistently taken into account at higher levels of the regional division, which caused a cascading accumulation of deviations (Lewandowski 1985; Richling & Lechnio 2005; Richling et al. 2012; Lechnio & Malinowska 2018; Richling et al. 2018).

The division of the former Suwałki Voivodship into physico-geographical microregions should also be mentioned (Richling 1985a, b). These units were distinguished without larger corrections of mesoregions according to their distinguishable parts, and this resulted in 37 individual units. Then, these microregions were grouped according to their typology, which resulted in the distinguishing of 9 types of microregions.

A. Richling is also the author of a detailed study of the regionalisation of the interfluvial



area of the Nurzec and the mid Bug (Richling 1976). Works conducted in this place served as the basis for the formulation of rules for one of the deductive methods for regionalisation. The same work presented regions of I, II and III rank in the vicinity of Suwałki. The third-level boundaries generally correspond to the boundaries of the mesoregions distinguished through the combination of smaller units into larger units in a consistent manner.

In 2005, R. Czarnecki published a division of the eastern part of the Sandomierz Upland into microregions. This was based on a detailed exploration of the area. The boundaries of the microregions were determined due to the analysis of the map presenting the low level types of geocomplexes.

A form of summary of the work performed by the Warsaw University research centre in the field of detailed regionalisation is a plate included in the Atlas of the Republic of Poland (the Atlas of the Republic of Poland 1994, plate 53.4), which presented the microregionalisation of the areas around Płock, Giżycko and Kielce at a 1:200,000 scale, which was developed by J. Kondracki and A. Richling, and of the area around Nowy Sącz produced by K. German and J. Kondracki.

Among work developed in Warsaw, the work of J. Borzyszkowski and M. Biłtasik (2016) from the Institute of Environmental Protection – National Research Institute should also be mentioned. These authors presented their own version of a detailed physico-geographical division of the Podkarpackie Voivodship, the eastern part of the Małopolskie Voivodship and the southern part of the Lubelskie Voivodship, i.e. an area covering 24 mesoregions within 5 macroregions. They based their division into microregions mainly on features of the terrain relief, assuming the general rule that it reflects the interior structure of a given area and all the processes producing its diversity. It should be mentioned that the proposed division differs in many ways from the proposal of W. Ziaja (2009), although they are both based on the regionalisation of J. Kondracki.

Studies on the regional division of the western Poland had been carried out at the Adam Mickiewicz University in Poznań since the 1930s. Among these older studies, special attention should be drawn to the article by S. Pawłowski (1931), who saw the need for the regional division of the country and carried out the division of Wielkopolska into regions on the basis of geomorphological criteria. These works were continued after the Second World War and resulted in the subdivision of the Wielkopolska-Kujawy Lowland into regions and subregions according to the geomorphological criterion (origin-related types of terrain relief) performed by B. Krygowski (1961). Moreover, A. Marsz (1966a, b, c) published the methodological assumptions used to distinguish regional physico-geographical units and performed the physico-geographical division of Wolin Island. Several years later, T. Bartkowski (1968a, b) published the division of the Wielkopolska Lowland into orographic units and the division of north-eastern Poland into physico-geographical regions. Two years later, he published another regionalisation of Wielkopolska and the Middle Odra area on the basis of a comprehensive approach (Bartkowski 1970a). He took the following features as criteria for the division into physico-geographical regions: geological structure, terrain relief, (genesis and morphometry), water relations, climate, soil and vegetation. In comparison with the division of B. Krygowski (1961), he adopted a greater degree of generalisation. A similar approach was applied by L. Kozacki (1970), who divided the northern part of the Konin district into microregions for the purpose of the assessment of changes in the natural environment, while in the microregionalisation of this area he applied the following criteria: geological structure, morphometry, surface and ground water, soil, local climate and land cover. The same set of criteria were used by S. Żynda (1978) in his division of the Middle Odra area into the physico-geographical units. It should be also mentioned that T. Bartkowski (1970b) called for the division of the country into microregions, discussing also

the methodology of this division. A slightly different methodology of distinguishing microregions was proposed by L. Kozacki, A. Marsz and S. Żynda (1970) in which terrain morphometry and dominant land use type were adopted as the basis for selection. Using a different methodology, T. Bartkowski and T. Tomkiewicz (1975) carried out the division of the Leszno – Sława Śląska area into microregions. They carried out an analysis of microregionalisation, although based on slightly different criteria, which indirectly indicated the need to change the mesoregion boundaries. Following the heyday of work on regionalisation, there was a break in the Poznań centre which lasted until the first decade of the 21st century. In 2013, D. Łowicki and A. Mizgajski published an article in which they called for the typology of physico-geographical regions and the verification of the mesoregion boundaries as identified by J. Kondracki on the basis of the structure of the land cover and the changes that had occurred. They stated that mesoregions distinguished on the basis of criteria applied by J. Kondracki do not fully reflect the structure of the land cover. They assessed that the land cover may be one of the representative features in regional studies. In connection with the landscape audit prepared in the Poznań centre over the most recent period, the team composed of: A. Macias, S. Bródka and W. Piniarski from the Department of the Landscape Ecology at the Adam Mickiewicz University developed a completely new and original subdivision of Wielkopolska into microregions by applying an inductive (bottom-up) approach, i.e. starting from uniform physico-geographical units, through microregions, and ending with mesoregions. The starting point was a digital database of individual components of the natural environment and the criteria: geological structure, origin-related types of terrain relief, downslopes, the first groundwater level, origin-related types of soil, land cover and potential vegetation habitats.

The area of the contemporary Kujawsko-Pomorskie Voivodship (or at least significant sections of it) was subject to different

physico-geographical regionalisations performed by authors from various centres. These works were carried out with the use of different methods and at different scales. Apart from the work of J. Kondracki which covered the entire territory of Poland, the work of R. Galon (1931, 1934, 1947, 1973, 1984), B. Krygowski (1956, 1961), A. Krażewska (1963), T. Bartkowski (1970a), J. Szczepkowski (1977), T. Gacki and J. Szukalski (1982), R. Dysarz (1996) and the recent work of T. Giętkowski (2008) deserve special attention. Over the past twenty years, the issues of the regionalisation of this area were mainly dealt with at the Nicolaus Copernicus University in Toruń. The work of L. Andrzejewski and R. Kot (2006) classified different subdivisions into regions of similar rank in the vicinity of Toruń, which reflected the difficulties in determining boundaries and the ambiguity of the subdivision into regions, even in the case of the application of the same (at least formal) criteria. The methodological aspects and examples of the verification of the boundaries of valley lowland areas were presented by R. Kot (2008, 2009). New proposals for the regional boundaries for selected areas of the last glaciation of the Polish Lowlands were shown through examples in the Łąwa Lakeland, the Masurian Lakeland and the Wielkopolska-Kujawy Lakeland (Kot 2011). The regionalisation work was intensified thanks to the preparation of the Internet Atlas of the Kujawsko-Pomorskie Province (Internetowy Atlas Województwa Kujawsko-Pomorskiego – IAWKP). For the purpose of the IAWKP, the typological and regional classification was carried out for the voivodship at the general and overview scale. The assumptions adopted and procedures were based on the methodology and the previous division made by J. Kondracki (1998) and thematic maps prepared for the purposes of the IAWKP at similar scales enabled the preparation of digital maps of physico-geographical regions at the 1:1,000,000 and 1:500,000 scales (Kot 2015a, b, c). The maps that were developed were also published in printed form (Kot 2015d, e, f). The methodology

of the physico-geographical classification of the entire Kujawsko-Pomorskie Voivodship was discussed in detail in the work of R. Kot (2016). In physico-geographical regionalisations, the criteria for distinguishing the physico-geographical macroregions included the genesis of the terrain relief and the geological structure taken into account in subprovinces (Kot 2015a, 2016). Physico-geographical mesoregions were distinguished on the basis of the recognised detailed genesis of the terrain relief and lithology (lakeland, outwash plains, covered with forests), as well as morphometric traits (valley, plain) or the landscape structure (Kot 2016). A separate work (Kot 2017a) was dedicated to the characteristics of 25 physico-geographical mesoregions distinguished within the Kujawsko-Pomorskie Voivodship. The most recent projects at the Nicolaus Copernicus University in Toruń were focused on the regionalisation of river valleys and ice marginal valleys (Urstromtäler), conducted at very detailed scales (Kot 2017b). As a result, a new mesoregion was distinguished within the framework of the fragment of the Toruń-Eberswalde Ice Marginal Valley (Kot 2017b).

In addition to different versions of the most famous physico-geographical regionalisation using the decimal system developed by J. Kondracki, the entire Pomerania or its smaller parts has been subdivided into regions many times. In their overview article, M. Kistowski and J. Szydłowski (2018) listed 31 most important publications which present 24 regional physico-geographical divisions covering Gdańsk Pomerania, carried out in the 20th and 21st centuries. The regionalisations listed were developed by a total of 19 authors from various academic centres and in only 7 cases concerned the division of the entire territory of Poland (in different national borders), whereas the other work covered different parts of Pomerania. A significant part of the older work was carried out by B. Augustowski (1969, 1977, 1979), T. Gacki and J. Szukalski (Gacki & Szukalski 1979, 1982), and M. Przewoźniak (1985, 1993) and researchers in the Gdańsk geographical centre cooperating

with them, initially at the Pedagogical University, and then at the University of Gdańsk.

Despite a significant number of pieces of regionalisation work, the only comprehensive regional division of Pomerania (developed to the level of a physico-geographical mesoregion) was made by B. Augustowski (1977). The area of the Gdańsk Voivodship using the 1975-98 boundaries constitutes the largest continuous part of Pomerania for which regionalisation was developed to the microregion level (Przewoźniak 1985). Other work covering smaller parts of the area focused on the coastal and lakeland regions, most representative of Pomerania.

At the Gdańsk centre, the most dynamic development of the work on regionalisation took place between 1965 and 1985. The period from the beginning of the 1990s until the present was characterised by stagnation; individual investigations copied earlier work or made only small corrections to boundaries. Only the work of M. Przewoźniak (1993) covering 5 seaside voivodships and the 7 voivodships adjacent to them deserves to be remembered from this period. In order to distinguish macroregions and mesoregions, the Author used a relatively broad set of criteria which included features of the relief and land cover as well as the lithology of surface sediments and origin-related types of soil. Another publication from this period is the work on the Starogard Lakeland (Rolka 1996), which used microregions previously distinguished by other authors. However, the units resulting from this classification raise some questions due to the lack of a list of delimitation criteria.

Since 2013, there has been a renewed interest in regionalisation issues at the University of Gdańsk, which is reflected in the work of a methodological character carried out by J. Szydłowski (2013) (Kistowski & Szydłowski 2014). The purpose of these research studies was to develop and test the inductive method of physico-geographical regionalisation with the use of GIS software. New boundaries of meso- and microregions were proposed on the basis of the analysis of geocomplexes distinguished in five research fields with

an area of 25 km x 25 km in which five criteria were applied: terrain relief (downslopes), lithology of surface sediments, depth of the first groundwater level, origin-related types of soil and land cover. The studies confirmed the usefulness of the GIS software for the purposes of the regionalisation, although at the same time the inductive method proved to be very laborious at the level of work detail that can be anticipated when working at a scale of approximately 1:50,000.

The previous proposals for the regional division of Pomerania, carried out in different periods and on the basis of similar but not identical criteria, produced clearly different boundaries, even in the case of mesoregions which appear to have a clear identity. This for example applies to the Kashubian Lakeland. Therefore, this area was chosen for a detailed analysis by M. Kistowski and J. Szydlowski (2015). Both the delimitation of the region and the division into microregions were performed by the inductive method on the basis of the analysis of the terrain relief (processing of the Digital Terrain Model into hypsometry, downslopes and a topographic wetness index) as well as the lithology of surface sediments supplemented by information about the water network (Kistowski 2018). Nevertheless, the works also used results from previous analyses involving the inductive approach.

The common feature of studies carried out over recent years at the University of Gdańsk, in a similar manner to studies on Pomerania carried out in other centres, is the application of GIS software during the delimitation of regions or at least in order to visualise and analyse the units distinguished. The work of T. Giętkowski (2008), for example, concerned the boundaries of the Tuchola Forest mesoregions, and resulted in the identification – against the background of previously performed regionalisation – of the original boundaries on the basis of the analysis of the terrain relief (processing of the Digital Terrain Model into maps of downslopes, slope exposure, denivelation), lithology of surface sediments and elements of the water network and land cover.

In Western Pomerania, at the Szczecin centre (West Pomeranian University of Technology), the physico-geographical regionalisation did not constitute an important direction of studies. Over recent years, it was emphasised that – at least on young glacial areas – the contemporary landscape matrix (expressed in categories of land cover) may be a useful criterion for the verification of the boundaries of physico-geographical units of different rank. At the same time, it was particularly indicated that the clear change of the landscape matrix within the mesoregion may suggest the purposefulness of analyses, confirming the correctness of boundaries or indicating the possible necessity of correcting their selected parts (Pieńkowski & Podlasiński 2017).

The above review shows that, after many years of stagnation, there has been a renewed interest in the issues of regionalisation in recent years in most geographical centres in Poland. Numerous studies have been carried out at the regional level, discussion took place on the theory and methodology of regionalisation and a team of specialists was formed. Their experience enabled this work to be carried out.

### **New regionalisation: Approaches and Data**

According to J. Kondracki (1977), the following factors play a crucial role in distinguishing macroregions: geographical location, character and origin of the terrain relief and lithological diversity. He adopted the same criteria – but at a more detailed level – to distinguish mesoregions. This set of criteria, basically acceptable for determining boundaries at overview scales (1:300,000 – 1:500,000) is too general and ambiguous when it comes to delimitation of mesoregions at a detailed scale (e.g. 1:50,000). It results in the occurrence of significantly different interpretations concerning the boundaries. The differing results of the regionalisation may be connected to the attaching of great importance to individual geomorphological features

(morphological, morphometric, morphogenetic, morphochronological) and lithological features (mainly stratigraphic, but also mineralogical and petrographic). They may be also connected with the necessity, intuitively accepted by researchers, of dealing with these features in a different way in relation to mountain, upland and lowland regions.

In order to minimise the possibility of diverging interpretations within a multi-person team performing the study, several additional conventions and assumptions were arbitrarily adopted. First of all, it was generally agreed in accordance with works of Prof. J. Kondracki that the distinguishing of a given area as a mesoregion is determined mainly by the morphogenetic – geomorphological and geological – tectonic features in its surface layers (to a depth of 10-20 metres, rarely deeper), which is reflected in the relief of the ground surface and significantly influences the functioning of the area. In order for spatial units to be distinguished as mesoregions, they must be characterised by a compactness of geometry and similarity of morphological and morphometric features in their individual parts (including also the repeatability of their landforms and their origin background).

In the case of those areas with the highest geomorphological-geological diversity and largest collection of co-occurring endo- and exogenetic effects, i.e. in the case of uplands and mountains, as the key aspect of physico-geographical regionalisation, the boundaries of those landforms connected with fold and fault tectonics producing structural relief were accepted. The studies took into account those boundaries which have an impact on the current structure and functioning of the landscape and which occur on the surface or at a sufficiently shallow depth to have this impact. Furthermore, the morphogenetic diversity connected with exo-origin was assessed which to a great extent is responsible for the contemporary character of the relief. Finally, the diversity of morphometric and morphological features, including mountain ridges, denivelation, and land

slopes, was taken into account. Stratigraphy considers stratigraphic features, in the origin-related context, as additionally connected with morphogenesis and morphochronology and lithographic features were treated in this context.

In lowland areas two environmental features: the geological structure and terrain relief, were the main criteria of the division. In relation to the geological structure, the leading feature was the lithology (composition) of surface sediments. In relation to terrain relief, the leading feature was provided by downslopes resulting from the spatial distribution of altitude expressed on a hypsometric map. At the same time, the studies took into account the character of the mosaic of the following landforms: concave features such as valleys, ribbon and basin landforms (frequently filled with lake water or directly drained by streams) and convex features which include accumulative landforms of different origin (e.g. glacial, aeolian and denudational). The above characteristics were simultaneously related to the morphogenesis and morphochronology of terrain. In some cases, where there were no significant morphogenetic differences, supplementary data which concerned the distribution of surface waters, the depth of the first groundwater level and types of soil were used for the delimitation of mesoregions.

The regional diversity of the extension of the last glaciation in Poland was also considered to be crucial since it influenced the changeability of the relief and the quality of bedrock and because these allow for inclusion of morphogenetic and morphochronological criteria. It was assumed that in the case of the occurrence of many stages of extension of the last glaciations in close proximity, the region may be characterised by the presence of forms typical of marginal zones of different extents of the glaciation (e.g. in north-eastern Poland), contrary to the western part of the country where there was significant advance of the glaciated areas.

In the case of river valleys, the upper edge of the valleys was used – by convention

– to determine the boundaries, although without taking into account side valleys cut into the edge area.

In the case of proposals for the division of a large mesoregion into smaller parts, the internal diversity of the newly distinguished units was analysed and compared with the diversity between mesoregions with similar geomorphological features.

Despite adopting more precise criteria for determining the boundaries between mesoregions, the researchers encountered cases causing a lot of difficulties in interpretation. This was not only a result of the quality of the available materials, but also from the occurrence of wide transition zones between well distinguished areas and a lack of compatibility between the changeability of the lithology, genesis and vertical layout of the terrain. In such cases, the variation in the relief and the character of soil dominant on the surface were the criteria most frequently used in decision making.

All persons and teams working on the regionalisation used the following basic materials: (a) 1:50,000 topographic map of Poland (Head Office of Geodesy and Cartography), (b) 1:10,000 map of the hydrographic division of Poland (Institute of Meteorology and Water Management), (c) Digital Terrain Model (Head Office of Geodesy and Cartography) produced on the basis of data from the ISOK (IT system of the Country's Protection Against Extreme Hazards) Project which had a value of average altitude error not exceeding 0.2 m in the ARC/INFO ASCII GRID format. If there was no digital model of the terrain relief of the above parameters, the studies used data from the LPIS Project with a value of average altitude error falling between 0.2 – 2.0 m in the ESRI TIN format, (d) 1:50,000 Detailed Geological Map of Poland (Polish Geological Institute – National Research Institute), (e) 1:50,000 Lithogenetic Map of Poland (Polish Geological Institute – National Research Institute).

In addition to the general set of materials, all researchers used cartographic materials and descriptive geological, geomorphological

and soil materials referring to individual regions and carried out at different scales, numerous detailed geomorphological publications (including works concerning the more accurate description of the boundaries of the individual stages of glaciation and the identification of the character and genesis of geomorphological landforms), as well as the results of microregionalisation work previously carried out, largely unpublished, which belonged to individual authors and centres.

## New regionalisation: Results

The final version of the proposed modification of the physico-geographical mesoregions of Poland is shown on a separate map, inserted into the paper<sup>2</sup>.

All the changes introduced in the division of Poland into physico-geographical mesoregions can be grouped in five categories: (a) the division of a mesoregion into two or more new mesoregions; (b) distinguishing a new mesoregion at the border of two previously existing mesoregions; (c) combination of mesoregions into a new one; (d) a clear change of the mesoregion area; (e) more precise delineation of the mesoregion's boundaries without a significant change in its area.

A good example of division into two or more new mesoregions is the Poznań Lakeland (315.51), which currently is treated as three mesoregions: the Poznań Lakeland (315.51) in a narrow sense, the Nowy Tomyśl Plain (315.50) and the Grodzisk Heights (315.59) (Fig. 1A). The division into three sections results from clear geomorphological differences. The northern part (Poznań Lakeland in a narrow sense) is of typical lakeland character, whereas the western part (Nowy Tomyśl Plain) is a distinctive outwash plain. The south-eastern part (Grodzisk Heights) is, on the other hand, devoid of lakes.

The regionalisation presented is characterised by the consistent marking of narrower sections of gorge (gap) character

<sup>2</sup> Digital version of the map in ESRI shp format is available on the *Geographia Polonica* home page.



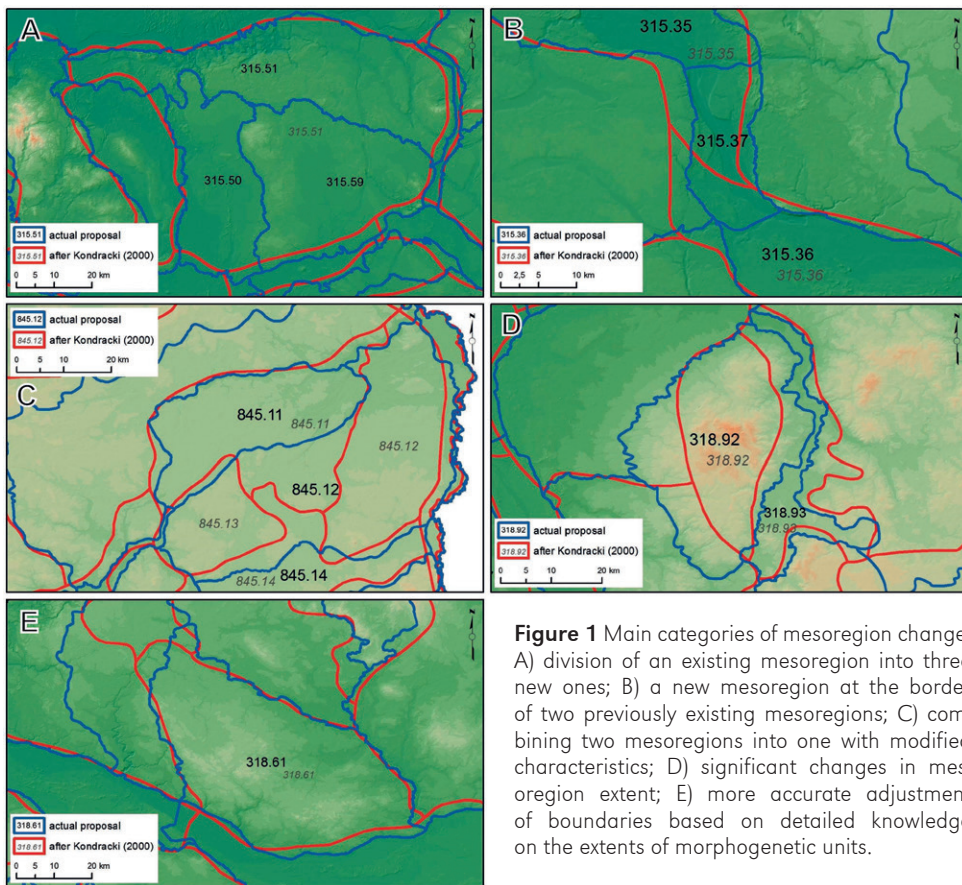
and wider sections of basin character in the largest Polish river valleys. According to this scheme, a new mesoregion (315.37), the Nieszawa Gap of the Vistula River, was distinguished in the Vistula River valley at the border between two previously distinguished mesoregions (Fig. 1B). Similarly a new gorge section, the Racibórz Gate (318.50), was proposed in the Odra valley.

One of the changes introduced concerns the combination of two functioning and neighbouring mesoregions into one mesoregion. Such a situation occurred in the case of the Kodeń Plain (845.12) and the Parczew Plain (845.13). It was proposed to form one mesoregion – the Parczew-Kodeń Heights (845.12), of the two combined and slightly increased by parts of neighbouring regions: the Łomazy Depression (845.11) and the

Sosnowica Depression (845.14). They were combined on the basis of the results of new research confirming the uniform character of the entire area (Fig. 1C).

Moreover, a portion of the mesoregion changes resulted from significant inclusions or exclusions of parts of areas from neighbouring regions. The change in the extent of the following mesoregions in the Lublin region may serve as an example: the Kałuszyn Heights (318.92) and the Węgrów Depression (318.93). On the basis of results of recent geomorphological studies, it was proposed to significantly increase the area of the Kałuszyn Heights, whereas the neighbouring Węgrów Depression region was significantly narrowed (Fig. 1D).

In the case of most of the mesoregions, previously distinguished by J. Kondracki, the



**Figure 1** Main categories of mesoregion change: A) division of an existing mesoregion into three new ones; B) a new mesoregion at the border of two previously existing mesoregions; C) combining two mesoregions into one with modified characteristics; D) significant changes in mesoregion extent; E) more accurate adjustment of boundaries based on detailed knowledge on the extents of morphogenetic units.

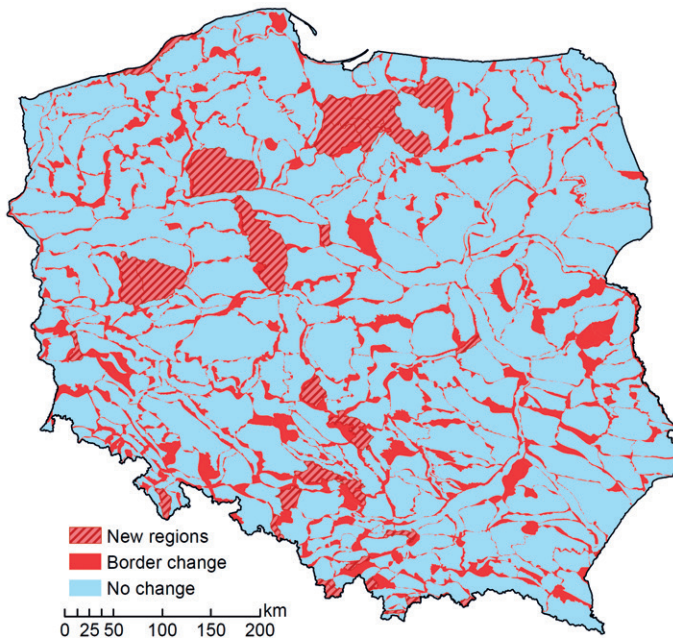
boundaries were moved to a lesser extent, which resulted from these regions being more accurately determined at a 1:50,000 scale. This is connected with the adjustment of regions' boundaries to take account of the more detailed extents of morphogenetic units, generally at their erosive borders (slope upper edge) in the case of river valleys and fluvio-glacial forms and at their structural – denudational borders in the case of the extents of upland and mountain areas. The extent of the Płock Heights (318.61), whose approximate boundaries seen in the regionalisation of J. Kondracki were made more specific at 1:50,000 scale (Fig. 1E), was presented as an example.

The largest changes in the sizes and shapes of mesoregions were made in the following areas (Fig. 2):

- the area of the Kłodzko Basin, where the creation of the Upper Nysa Graben (332.55) mesoregion was proposed, which is clearly distinguishable from the remaining part of the Kłodzko Basin mesoregion. The Upper Nysa Graben is a latitudinal

furrow with clear boundaries to the east and the west, with tectonic thresholds of up to 500 metres. The new Kłodzko Basin mesoregion is a compact depression at the confluence of four rivers: the Nysa Kłodzka, the Ścinawka, the Bystrzyca Dusznicka and the Biała Łądecka, with unclear borders with neighbouring mountain ranges, even with bottom and quaternary sediments. Moreover, significant changes were proposed in the region of the Orlickie Mountains, the Bystrzyckie Mountains and the Stołowe Mountains as a result of attaching a significant part of the existing Orlickie Foothills mesoregion to these regions.

- the area connected with the upper section of the Odra River, concerning the following existing mesoregions: the Racibórz Basin (318.59), the Wrocław Ice Marginal Valley (318.52), the Głubczyce Plateau (318.58), the Rybnik Plateau (341.15), the Opole Plain (318.57) and the Niemodlin Plain (318.55). It is proposed to introduce spatial changes in the region of the above



**Figure 2** Areas which changed allocation to mesoregions (comparison of the actual proposal with the version of Kondracki 2000)



mentioned mesoregions which take into account the fact that they belong to geomorphological units of higher rank, as well as the structure of their bedrock and their relief development. It is proposed to combine part of the Wrocław Ice Marginal Valley with the neighbouring Opole Hummock and to include this hummock in the Opole Plain. Moreover, it is proposed to divide the Opole Plain into the western part under the same name and the eastern part under the name of Upper Mała Panew Depression (341.28). It is also proposed to move the western boundaries of the Opole Plain to the Stobrawa valley.

- the area connected to the Bydgoszcz – Płock section of the Vistula Valley, the Noteć River in the region of Nakło and the area of Kujawy, where it was proposed to introduce significant changes in the extents of individual mesoregions, as well as the creation of a new mesoregion of the Nieszawa Gap of the Vistula River (315.37). It is a clearly distinguishable section of the valley between the Toruń Basin and the Płock Basin. The changed geometry of the Kuyavian mesoregions is justified by spatial geomorphological systems. Numerous changes in the extents of the: Chełmno Lakeland, Brodnica Lakeland and Dobrzyń Lakeland mesoregions are connected with detailed data on the structure and genesis of the bedrock in these regions.
- the area of the western part of the Silesian-Kraków Upland, where significant changes were proposed in the areas of many mesoregions, especially in the area of the Katowice Upland, the Racibórz Gate and the Tarnowskie Góry Hummock. Changes of the geological structure, frequently resulting in changes of the relief, were used as the main criteria for the modifications.
- the area of the Western Carpathians, where new mesoregions were created. Their relief differs from the relief in other existing areas, for example in the Żywiec Beskid Mts, in the Tatra and sub-Tatra regions, and in the Sącz Beskid Mts.

- areas of existing large mesoregions: the Poznań Lakeland (315.51), the Olsztyn Lakeland (842.81) and the Łąwa Lakeland (314.90) as well as the Krajna Lakeland (314.69). In the case of the first 3 regions, it was proposed to divide each of them into 3 new mesoregions, and the Krajna Lakeland into 2 mesoregions.

Other changes in the mesoregions are local and concern one or two neighbouring regions, for example in the valley of the Pilica river, the Koźienice Plain, the Jasło-Krosno Basin, the valley of the mid Bug, and the coastal zone of the Baltic Sea.

In general, almost 69.5 thousand km<sup>2</sup> (approx. 22% of the area of Poland) changed allocation to their mesoregion, and over 17 thousand km<sup>2</sup> of this area was due to the establishment of quite new mesoregions (Fig. 2).

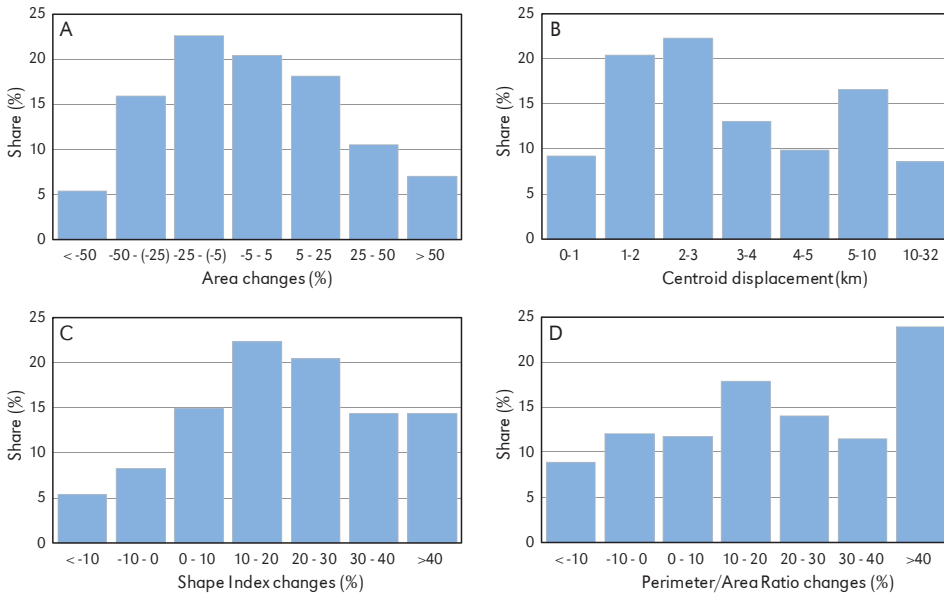
The verification resulted in an increase in the number of mesoregions from 316 to 344 and in changes in the spatial and geometric characteristics of mesoregions (Tab. 1, Fig. 3). The average area of a mesoregion decreased from 986.9 km<sup>2</sup> to 907.5 km<sup>2</sup>. In the case of almost 16% of mesoregions their area decreased by more than 25%. Small changes (in the range from -5 to 5%) occurred in the case of approx. 20% of the total number of mesoregions, while an increase in area greater than 25% occurred in almost 18% of mesoregions.

Changes in the area of mesoregions resulted in the displacement of the centroids of the regions. The average shift was 4362 m with a minimum of 54 m and maximal value of 31,680 m. Generally changes were rather small: for 10% of mesoregions – less than 1 km, while for 40% shifts were in the range of 1-3 km. It is worth underlining that large displacements, above 10 km, occurred in only 9% of mesoregions. Those changes were mainly due to division of big mesoregions into smaller ones.

As a result of the more precise delineation of the boundaries of the mesoregions the values of indicators of boundary complexity clearly increased. The Mean Shape Index

**Table 1.** Main changes of mesoregions' geometric properties

| Variable                    | Present study | Kondracki (2000) |
|-----------------------------|---------------|------------------|
| Number of mesoregions       | 344           | 316              |
| Mesoregion Area - mean (ha) | 90,750        | 98,687           |
| Mesoregion Area - min (ha)  | 605           | 1,523            |
| Mesoregion Area - max (ha)  | 377,854       | 431,834          |
| Shape Index - mean          | 1.980         | 1.641            |
| Shape Index - min           | 1.234         | 1.071            |
| Shape Index - max           | 10.004        | 4.566            |
| Perimeter/Area Ratio - mean | 3.50          | 2.68             |
| Perimeter/Area Ratio - min  | 1.00          | 0.60             |
| Perimeter/Area Ratio - max  | 34.80         | 23.20            |
| Fractal Dimension - mean    | 1.19          | 1.17             |
| Fractal Dimension - min     | 1.14          | 1.12             |
| Fractal Dimension - max     | 1.37          | 1.30             |



**Figure 3** Values of the chosen indicators characterising the spatial pattern of the mesoregions

increased from 1.641 to 1.980, Mean Fractal Dimension from 1.17 to 1.19, and Mean Perimeter/Area Ratio from 2.68 to 3.50. But those changes were not unidirectional. For some mesoregions complexity decreased (14% of mesoregions according to Shape Index, and 21% according to the Perimeter/Area Ratio). The greatest (more than 30% of previous values) increase in boundary

complexity occurred in the case of 29% of mesoregions (according to SI changes) and 35% (according to PAR values).

**Final remarks**

The division into mesoregions, shown in this article, is not a simple compilation of the previously published suggestions, but it forms

a piece of work, which can be characterised as new, creatively developing, and reconciling the proposals of the majority of national specialists dealing with such subject matters. Yet, it is not an entirely closed piece of research, but only work that illustrates the improvement of knowledge in the sphere of the environment and the development of views in a specific period of time. Issues that will require further detailed work in the future were identified during the completion of the work. Among such issues, special attention must be paid to the problem of the identification and appropriate description of cross-border regional units, which cover a very small area in Poland, and whose area is also situated on the other side of borders. Initially, one should indicate the area of the San-Dniester Plateau, which covers about 88 km<sup>2</sup> in Poland but extends much further in Ukraine, covering hundreds of square kilometres there. Some of the regions on the border between Poland and Slovakia as well as Poland and Czechia also require additional agreements.

Yet another issue requiring further analysis in the future relates to the regionalisation of transition zones between the Polish lowlands, uplands and mountains. These studies cause many significant problems in their interpretation. The key issue is the interpretation of extent of occurrence of ridges and depressions between ridges. In the southern part of the uplands, they are distinct due to clear tectonics and a relatively low influence of glacial, fluvio-glacial and fluvial processes slightly changing older relief. In the north-eastern part of the uplands, the structural relief has been radically transformed due to the ice sheets of the old glaciations. Glacial sediments have covered depressions between ridges and partly built up the outcrops of the formations creating them. The river network was deformed, conditioned by the structural relief, which in the past used depressions between ridges to discharge water. In some sections, the upper reaches of river valleys do not use former depressions but cross them along gorges. The necessity of defining this section of the boundary between the uplands

and lowlands along ridges with Triassic and Jurassic outcrops is not controversial, but the detailed delineation still should be subject to further studies.

Moreover, efforts to correct J. Kondracki's regionalisation carried out by representatives of different centres from southern and central Poland revealed numerous, sometimes divergent views on the boundaries of physico-geographical units. It resulted, to a great extent, from the research traditions of a given centre (e.g. the traditions of the Kraków, Silesian or Łódź centres). Most researchers used the same basic criteria for distinguishing a given unit, but the results of boundary determination were initially different. It resulted from different approaches to the importance and rank of individual criteria, as well as the change of their primacy and relative weight in different parts of the area in question. One example of such a situation was the adoption of overriding structural-tectonic criteria in the determination of physico-geographical unit boundaries in the southern part of the Kraków-Częstochowa Upland, but with the use of geomorphological (quaternary) criteria in the central and northern parts of this Upland. A final clarification and meshing together of different opinions gave the joint proposal for regionalisation for this area, but it is still open to some questions dealing with "objectivity" and the "weight" of qualitative and quantitative differences between adjacent regions, as well as the width of the boundaries between them.

Similar, although not the same problems arose in the regionalisation of middle and northern Poland, on the transition zones between areas subjected to the influence of different phases of glaciation. The good example is the boundary between the Siedlce Heights (hummocky upland moraine) and the Łuków Plain (outwash plain) – one of areas that is problematic due to small downslopes. On the basis of the latest detailed geological and geomorphological research, it was proposed to define its boundaries along the southernmost consistent marginal forms of the final or retreat stop of the ice sheet

of the Warta glaciation. Following this proposal and in relation to the idea of J. Kondracki, the Siedlce Upland may be defined as a mesoregion generally formed as a result of the disappearance of the ice sheet, and the Łuków Plain as a mesoregion formed mainly as a result of the outflow of snowmelt water.

The version of the regionalisation presented here has made progress in our understanding of differentiation in the natural environment in comparison with previous versions, and has simultaneously opened the field for new rounds of methodical discussions on more sophisticated and multidimensional approaches to the distinguishing and characterisation of spatial units of different ranks.

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Unless otherwise stated, the sources of tables and figures are the authors', on the basis of their own research.

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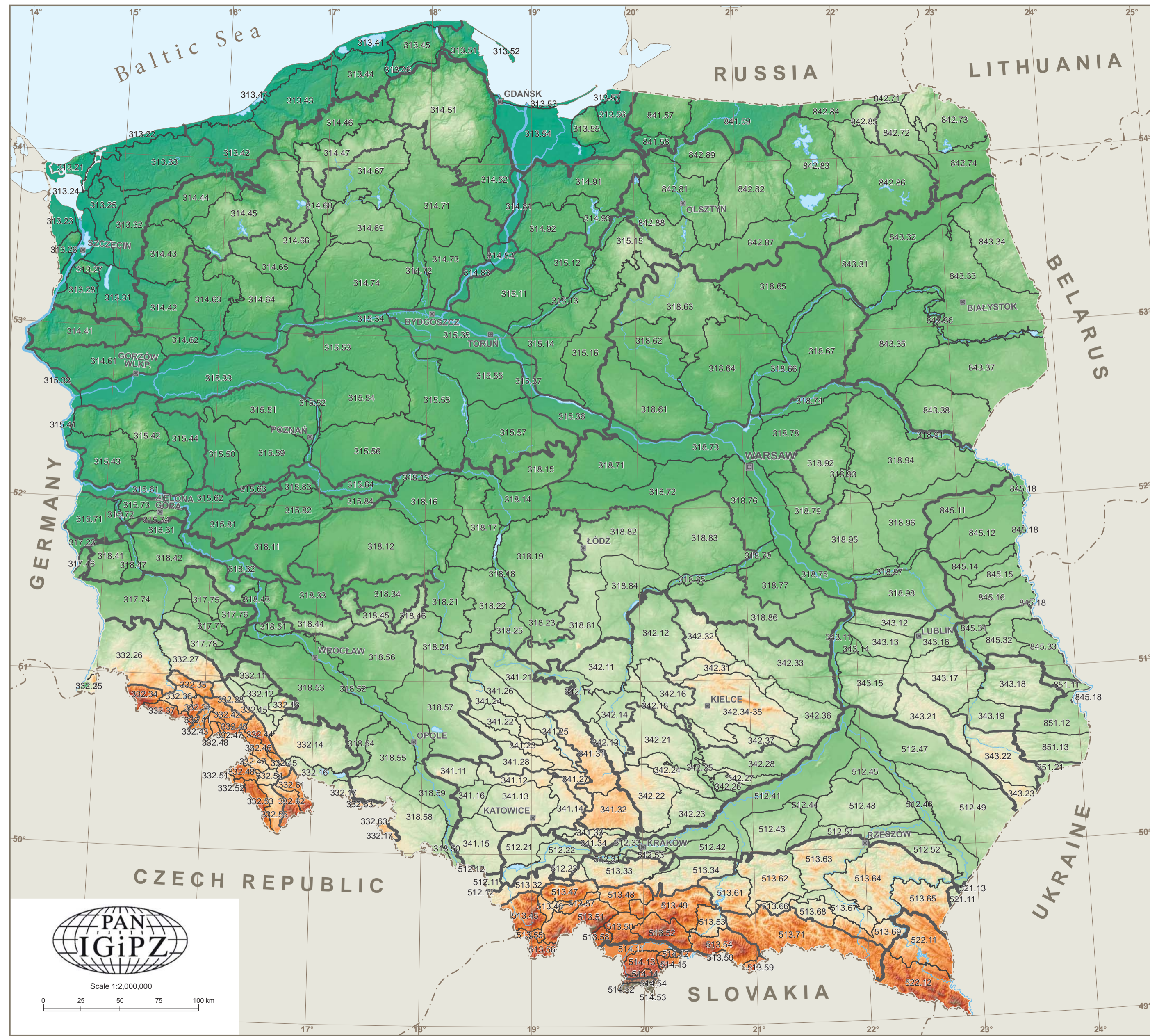


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MAP OF PHYSICO-GEOGRAPHICAL MESOREGIONS OF POLAND: MODIFIED VERSION OF J. KONDRACKI'S REGIONALISATION (map edited by Jerzy Solon and Jan Borzyszkowski)



**NAMES OF PHYSICO-GEOGRAPHICAL REGIONS**

**3 Beyond-Alps Europe**

- 31 Central European Lowland
- 313 Southern Baltic Coastlands
  - 313.2-3 Szczecin Coastland
    - 313.21 Uznam & Wolin Islands
    - 313.22 Trzebiatów Coast
    - 313.23 Police Plain
    - 313.24 Lower Odra River Valley
    - 313.25 Goleniów Plain
    - 313.26 Szczecin Heights
    - 313.27 Bukowe Hills
    - 313.28 Weliński Plain
    - 313.29 Pyrzyce Plain
    - 313.30 Nowogard Plain
    - 313.31 Gryfice Plain
  - 313.4 Koszalin Coastland
    - 313.41 Słowinian Coast
    - 313.42 Białogard Plain
    - 313.43 Stupsk Plain
    - 313.44 Darnnica Heights
    - 313.45 Choczewo Heights
    - 313.46 Reda-Łeba Proglacial Valley
  - 313.5 Gdańsk Coastland
    - 313.51 Cassubian Coastland
    - 313.52 Hel Peninsula
    - 313.53 Vistula Spit
    - 313.54 Żuławki Alluvial Plain
    - 313.55 Elbląg Heights
    - 313.56 Warmia Plain
    - 313.57 Old Prussian Coast
- 314-316 Southern Baltic Lake Districts
- 314.4 Western Pomerania Lakeland
  - 314.41 Myślubórz Lakeland
  - 314.42 Choszczno Lakeland
  - 314.43 Insko Lakeland
  - 314.44 Łober Heights
  - 314.45 Drawsko Lakeland
  - 314.46 Polanów Heights
  - 314.47 Bytów Lakeland
  - 314.5 Eastern Pomerania Lakeland
    - 314.51 Cassubian Lakeland
    - 314.52 Starogard Lakeland
  - 314.6-7 Southern Pomerania Lakeland
    - 314.61 Gorzów Plain
    - 314.62 Dobiegniew Lakeland
    - 314.63 Drawa Plain
    - 314.64 Wałcz Lakeland
    - 314.65 Wałcz Plain
    - 314.66 Szczecinek Lakeland
    - 314.67 Charzykowy Plain
    - 314.68 Gwda River Valley
    - 314.69 Northern Krajina Lakeland
    - 314.71 Tuchola Forest
    - 314.72 Brda River Valley
    - 314.73 Świecie Upland
- 314.8 Lower Vistula River Valley
  - 314.81 Kwidzyn Valley
  - 314.82 Grudziądz Basin
  - 314.83 Fordon Valley
- 314.9 Iława Lakeland
  - 314.91 Iława Plain
  - 314.92 Łasin Lakeland
  - 314.93 Dzierżgoń-Morąg Lakeland
- 315.1 Chełmno-Dobrzyń Lakeland
  - 315.11 Chełmno Lakeland
  - 315.12 Brodnica Lakeland
  - 315.13 Druwica River Valley
  - 315.14 Dobrzyń Lakeland
  - 315.15 Lubawa Hummock
  - 315.16 Urszulewo Plain
- 315.3 Toruń-Eberswalde Ice Marginal Valley
  - 315.32 Freienwalde Basin
  - 315.33 Gorzów Basin
  - 315.34 Middle Noteć River Valley
  - 315.35 Toruń Basin
  - 315.36 Płock Basin
- 315.4 Lubuskie Lakeland
  - 315.41 Lubuski Gap of the Odra River
  - 315.42 Łagów Lakeland
  - 315.43 Torzym Plain
  - 315.44 Zbąszyn Basin
- 315.5 Wielkopolskie Lakeland
  - 315.50 Nowy Tomyśl Plain
  - 315.51 Poznań Lakeland
  - 315.52 Poznań Gap of the Warta River
  - 315.53 Chodzież Lakeland
  - 315.54 Gniezno Lakeland
  - 315.55 Inowrocław Plain
  - 315.56 Września Plain
  - 315.57 Kuyavian Lakeland
  - 315.58 Żnin-Mogilno Lakeland
  - 315.59 Grodzisk Heights
- 315.6 Warta-Odra Ice Marginal Valley
  - 315.61 Middle Odra River Valley
  - 315.62 Kargowa Basin
  - 315.63 Middle Odra River Valley
  - 315.64 Śrem Basin
- 315.7 Zielona Góra Hills
  - 315.71 Gubin Heights
  - 315.72 Lower Bobr River Valley
  - 315.73 Czerwień Heights
  - 315.74 Zielona Góra Ridge
- 315.8 Leszczyńskie Lakeland
  - 315.81 Sława Lakeland
  - 315.82 Krzywiń Lakeland
  - 315.83 Kościan Plain

- 315.84 Żerków Heights
- 317 Saxony-Lusatia Lowlands
- 317.2 Lower Lusatia Basin
  - 317.23 Ząsiki Basin
- 317.4 Lusatia Hills
  - 317.46 Bad Muskau Hills
- 317.7 Silesia-Lusatia Lowland
  - 317.74 Dolnośląskie Forest
  - 317.75 Przemków Plain
  - 317.76 Lubin Heights
  - 317.77 Legnica Plain
  - 317.78 Chojnów Plain
- 318 Central Poland Lowlands
  - 318.1-2 Southern Wielkopolska Lowland
    - 318.11 Leszczyńska Heights
    - 318.12 Kalisz Heights
    - 318.13 Konin Valley
    - 318.14 Kolo Basin
    - 318.15 Kłodawa Heights
    - 318.16 Rychwał Plain
    - 318.17 Turek Heights
    - 318.18 Sieradz Basin
    - 318.19 Łask Heights
    - 318.21 Grabów Basin
    - 318.22 Złoczew Heights
    - 318.23 Szczerców Basin
    - 318.24 Wieruszów Heights
  - 318.3 Milicz-Głogów Depression
    - 318.31 Nowa Sól Depression
    - 318.32 Głogów Ice Marginal Valley
  - 318.33 Zmigrod Basin
    - 318.34 Milicz Basin
  - 318.4 Trzebnica Range
    - 318.41 Zary Hills
    - 318.42 Dalków Hills
    - 318.43 Ścinawa Depression
    - 318.44 Trzebnica Hills
    - 318.45 Twardogóra Hills
    - 318.46 Ostrzeszów Hills
- 318.5 Silesia Lowland
  - 318.50 Racibórz Gate
  - 318.51 Roślisławice Heights
  - 318.52 Wrocław Ice Marginal Valley
  - 318.53 Wrocław Plain
  - 318.54 Nysa Kłodzka River Valley
  - 318.55 Niemodlin Plain
  - 318.56 Oleśnica Plain
  - 318.57 Opole Plain
  - 318.58 Głubczyce Plateau
  - 318.59 Racibórz Basin
- 318.6 Northern Masovia Lowland
  - 318.61 Płońsk Heights
  - 318.62 Raciąż Plain
  - 318.63 Miawa Hills
  - 318.64 Ciechanów Heights
  - 318.65 Kurpie Plain
  - 318.66 Lower Narew River Valley
  - 318.67 Łomża Interfluve
- 318.7 Central Masovia Lowland
  - 318.70 Lower Pilica River Valley
  - 318.71 Kutno Plain
  - 318.72 Łowicz-Błonie Plain
  - 318.73 Warsaw Upland
  - 318.74 Lower Bug River Valley
  - 318.75 Middle Vistula River Valley
  - 318.76 Warsaw Plain
  - 318.77 Kozienice Plain
  - 318.78 Wolomin Plain
  - 318.79 Garwolin Plain
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  - 318.85 Białobrzegi Valley
  - 318.86 Radom Plain
- 318.9 Southern Podlasie Lowland
  - 318.91 Podlasie Gap of the Bug River
  - 318.92 Kaluszyn Heights
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  - 318.94 Siedlec Heights
  - 318.95 Żelechów Heights
  - 318.96 Łuków Plain
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New mesoregions are shown green italic

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- 343.1 Wyżyna Lubelska
- 343.11 Małopolski Przełom Wisły
- 343.12 Płaskowyż Nałęczowski
- 343.13 Równina Bełzycka
- 343.14 Obniżenie Chodelskie
- 343.15 Wzniesienia Urzędowskie
- 343.16 Płaskowyż Świdnicki
- 343.17 Wniosłość Gielczewska
- 343.18 Działy Grabowieckie
- 343.19 Kotlina Zamojska

### 343.2 Roztocze

- 343.21 Roztocze Zachodnie
- 343.22 Roztocze Środkowe
- 343.23 Roztocze Wschodnie

## 5 Karpaty, Podkarpackie i Nizina Panońska

### 51 Karpaty Zachodnie z Podkarpaciem

### 512 Podkarpackie Północne

- 512.1 Kotlina Ostrawska
- 512.11 Wysoczyzna Kończycka
- 512.12 *Kotlina Olzy*
- 512.2 Kotlina Oświęcimska
- 512.21 Równina Pszczyńska
- 512.22 Dolina Górnej Wisły
- 512.23 Podgórze Wilamowickie

### 512.3 Brama Krakowska

- 512.31 Rów Skawiański
- 512.32 Obniżenie Cholerzyńskie
- 512.33 Pomost Krakowski

### 512.4-5 Kotlina Sandomierska

- 512.41 Nizina Nadwiślańska
- 512.42 Podgórze Bocheńskie
- 512.43 Płaskowyż Tarnowski
- 512.44 Dolina Dolnej Wisłoki
- 512.45 Równina Tarnobrzeska
- 512.46 Dolina Dolnego Sanu
- 512.47 Równina Bilgorajska
- 512.48 Płaskowyż Kolbuszowski
- 512.49 Płaskowyż Tarnogrodzki
- 512.51 Pradolina Podkarpacka
- 512.52 Podgórze Rzeszowskie

Nowe mezoregiony oznaczono zieloną, pochylą czcionką

### 512.53 Podgórze Krakowskie

### 513 Zewnątrzne Karpaty Zachodnie

- 513.3 Pogórze Zachodniobeskidzkie
- 513.32 Pogórze Śląskie
- 513.33 Pogórze Wielickie
- 513.34 Pogórze Wiśnickie

### 513.4-5 Beskidy Zachodnie

- 513.45 Beskid Śląski
- 513.46 Beskid Mały
- 513.47 Beskid Makowski
- 513.49 Beskid Wyspowy
- 513.50 Pogórze Orawsko-Jordanowskie
- 513.51 Beskid Żywiecko-Orawski
- 513.52 Gorce
- 513.53 Kotlina Sądecka
- 513.54 Beskid Sądecki
- 513.55 *Międzygórze Jabłonkowsko-Koniakowskie*
- 513.56 *Beskid Żywiecko-Kysucki*
- 513.57 *Pasma Pewelsko-Krzeczowskie*
- 513.58 *Działy Orawskie*
- 513.59 *Pogórze Popradzkie*

### 513.6 Pogórze Środkowobeskidzkie

- 513.61 Pogórze Rożnowskie
- 513.62 Pogórze Ciepłkowickie
- 513.63 Pogórze Strzyżowskie
- 513.64 Pogórze Dynowskie
- 513.65 Pogórze Przemyskie
- 513.66 Obniżenie Gorlickie
- 513.67 Kotlina Jasielsko-Krośnieńska
- 513.68 Pogórze Jasielskie
- 513.69 Pogórze Bukowskie

### 513.7 Beskidy Środkowe

### 513.71 Beskid Niski

### 514-15 Centralne Karpaty Zachodnie

- 514.1 Obniżenie Orawsko-Podhalańskie
- 514.11 Kotlina Orawsko-Nowotarska
- 514.12 Pieniny
- 514.13 Pogórze Przedtatrzańskie
- 514.14 Bruzda Podtatrzańska

514.15 Magura Spiska

- 514.5 Łańcuch Tatrzański
- 514.52 Tatry Zachodnie
- 514.53 Tatry Wysokie
- 514.54 *Tatry Reglowe*

### 52 Karpaty Wschodnie z Podkarpaciem Wschodnim

- 521 Wschodnie Podkarpacie
- 521.1 Płaskowyż Sańsko-Dniestrzański
- 521.11 Podgórze Hermanowickie
- 521.13 *Płaskowyż Mościcki*

### 522 Zewnątrzne Karpaty Wschodnie (Beskidy Wschodnie)

- 522.1 Beskidy Lesiste
- 522.11 Góry Sanocko-Turczańskie
- 522.12 Bieszczady Zachodnie

### 8 Niż Wschodnioeuropejski

### 84 Niż Wschodniobałtycko-Białoruski

- 841 Pobrzeże Wschodniobałtyckie
- 841.5 Nizina Starogruska
- 841.57 Wzniesienia Górowskie
- 841.58 Równina Ormecka
- 841.59 Nizina Seppolska

### 842 Pojezierze Wschodniobałtyckie

- 842.7 Pojezierze Litewskie
- 842.71 Puszcza Romincka
- 842.72 Pojezierze Zachodniosuwalskie
- 842.73 Pojezierze Wschodniosuwalskie
- 842.74 Równina Augustowska

### 842.8 Pojezierze Mazurskie

- 842.81 Pojezierze Olsztyńskie
- 842.82 Pojezierze Mragowskie
- 842.83 Kraina Wielkich Jezior Mazurskich
- 842.84 Kraina Węgorapy
- 842.85 Wzgórze Szarskie
- 842.86 Pojezierze Elckie
- 842.87 Równina Mazurska
- 842.88 *Równina Olsztynka*
- 842.89 *Wysoczyzna Jeziorańsko-Bisztynecka*

### 843 Wysoczyzny Podlasko-Białoruskie

- 843.3 Nizina Północnopodlaska
- 843.31 Wysoczyzna Kolneńska
- 843.32 Kotlina Biebrzańska
- 843.33 Wysoczyzna Białostocka
- 843.34 Wzgórze Sokółskie
- 843.35 Wysoczyzna Wysockomazowiecka
- 843.36 Dolina Górnej Narwi
- 843.37 Równina Bielska
- 843.38 Wysoczyzna Drohiczyńska

### 845 Polesie

- 845.1 Polesie Zachodnie
- 845.11 Zakłęsłość Łomaska
- 845.12 Wysoczyzna Parczewsko-Kodeńska
- 845.14 Zakłęsłość Sosnowicka
- 845.15 Garb Włodawski
- 845.16 Pojezierze Łęczyńsko-Włodawskie
- 845.18 *Dolina Środkowego Bugu*

### 845.3 Polesie Wołyńskie

- 845.31 Obniżenie Dorohuckie
- 845.32 Pagóry Chełmskie
- 845.33 Obniżenie Dubieńskiego

### 85 Wyżyny Ukraińskie

### 851 Wyżyna Wołyńsko-Podolska

- 851.1 Wyżyna Wołyńska
- 851.11 Grzędą Horodelska
- 851.12 Kotlina Hrubieszowska
- 851.13 Grzędą Sokalska

- 851.2 Kotlina Pobuzza
- 851.21 Równina Belska

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