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Interdependences between landscape components – a case study in the Nida Basin

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Abstract: The nature of connections between components of the natural environment may determine the use of methods for identification of environmental units – geocomplexes. This paper presents an analysis of connections between selected environmental components on areas with four bedrock types: gypsum, loess, clay and sand. The test areas were located in the vicinity of Pińczów, Poland. The analysis allowed to indicate areas on which identification of geocomplexes using the leading factors method yields the best results.

Key words: geocomplex, delimitation, connections between components, Nida Basin

Introduction

In complex physical geography, the most frequently used (e.g. Kistowski 1997, Przewoźniak and Tabeau 1987, Lechnio 2005) and the oldest model of division of the landscape into natural units is the mosaic model (Richling 2004). This model assumes that landscape is a set of geocomplexes. A geocomplex is understood as a relatively closed section of the natural environment, consisting of normally (i.e. according to the laws of nature) connected components, which constitutes a whole as a result of the processes occurring within it and the interdependences of its components (Malinowska et al. 2004). One of the methods used to identify geocomplexes is the leading factors method (Richling 1979). This approach assumes differential roles of environmental components. Some of the components have a leading role and others are subordinate to the leading ones (Richling 2007). The former group usually consists of land relief and bedrock. On the opposite end of this scale there is plant cover, being a component both the most variable and the most prone to human impact (Solon 2008). It is assumed that the geocomplexes delimited taking into account the mentioned above components are similar to a great extent.

The aim of this paper is to investigate to what extent the mosaic of geocomplexes corresponds with the mosaic of soils. Two soil characteristics were taken into account: soil type – as the main level of soil description and soil textural class – as one of the physical properties of soils, which in very differentiated within the analyzed area. The analyses were performed for four test areas, located in the vicinity of Pińczów, and characterized by different bedrock types: gypsum, loess, clay and sand.

Test areas and their division into environmental space units

The test areas were located in Nida Basin (fig. 1) and had a rectangular shape of about 10 km2. Within each test area, geocomplexes were established with accuracy corresponding to 1:50 000 scale. According to the leading factors method, the delimitation criteria were:

• slope – 5 ranges were assumed: 0-3º, 3-6º, 6-10º, 10-15º and >15º, based on the erosion risk level (Zawadzki

1999, after Strzemski et al. 1973),
• land use – classification according to the Corine Land Cover database.
• geological bedrock – a simplified classification based on Detailed Geological Map of Poland (scale 1:50 000), which was modified through partial exclusion of rock formation origin.

Further analysis covered only the geocomplexes with the following bedrock types: gypsum (area A), loess (area B), clay (area C) and sand (area D).

The units of the gypsum area are dominated by low slope terrain (0-3º). They are mostly used for agricultural purposes. Geocomplexes with loess bedrock (area B) are characterized by significant land relief diversity. Slope within this group of geocomplexes reaches 10º. These areas consist mostly of farmland (arable land, complex crop systems and private allotment gardens as well as predominantly agricultural areas, with significant coverage by natural vegetation) but coniferous forests are also present. Areas with clay bedrock are mostly flatlands characterized by low slope, used for crops and as grassland, with a limited coverage by deciduous forests. The highest forest cover occurred in test area D, which consisted of geocomplexes with sandy bedrock and little variation in land relief.


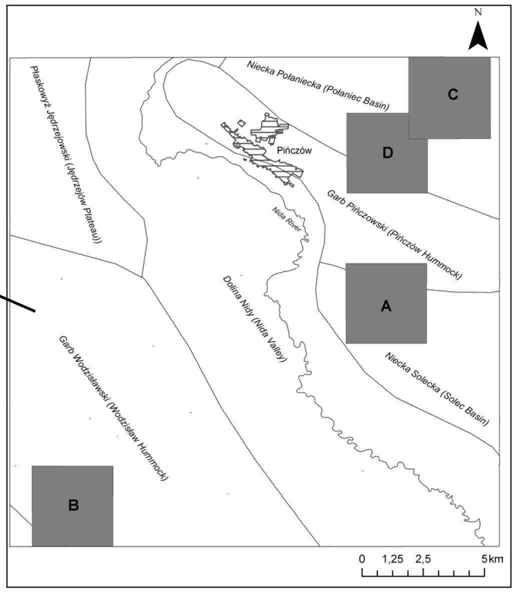

Fig. 1. Location of the test areas within mesoregions belonging to the megaregion of Nida Basin, according to the spatial division by J. Kondracki (1994). A – gypsum, B – loess, C – clay, D – sand area.

Methods of analysis

To analyse the relationships between environmental components two indices were used: 1) the relationship strength factor (Richling 1981) and 2) the relationship concentration factor (Ostaszewska 2002). According to A. Richling (1981) the relationship strength factor is calculated as a ratio of the area covered by all of selected feature categories of the analyzed components to the area covered by a category with a narrower range. A. Richling identifies three ranges for this index: 0.01-0.33, 0.34-0.66 and 0.67-1.00. The first one corresponds to a weak, the second one to a moderate and the last one to a strong relationship (Richling 1981). This index reaches the highest values when the range of the first feature area is contained in the area covered by the second feature.

The relationship concentration factor by K. Ostaszewska (2002) is defined as a ratio of the area covered by all the selected feature categories of the analyzed components to the area covered by at least one of the features. This index reaches the highest values when the ranges of feature classes of both components are identical. This allows to spatially determine the concentration of the analyzed relationship. K. Ostaszewska also created a formula for calculation of a general relationship concentration index for analyzed components (Ostaszewska

2002).
These indices were used to analyze relationships between geocomplex types determined using the leading factor method and the type and texture of soil. The source of data on the soil cover was the soil-agricultural map of the Pińczów area (scale 1:25 000) and a soil-habitat map created by the Pińczów Forest Division (scale 1:5000). In order to simplify analysis, soil textures on the analysed areas were grouped. The first group (1) was composed of all organic soil formations. The second group (2) consisted of loose sands and slightly loamy sands, as well as silty ones. The third group (3) comprised light loamy sands, silty light loamy sands and strong loamy sands and silty strong loamy sands. Light loam, silty light loam, medium loam, silty medium loam and light and medium rendzinas were included in the fourth group (4) The fifth group (5) consisted of soil formations with the highest content of clay fraction, i.e. heavy loams, silty heavy loams, heavy rendzinas, clays and silty clays. The last group (6) was composed of silts, silt loams, loess and loess-based soil formations.

Results

Relationships between geocomplex type and soil texture

The highest index of the strength of relationship between the analysed geocomplex types and soil texture was obtained for loess-based areas (test area B). This is linked to the uniform texture of the soil cover of all the geocomplex of this type (soil type group 6). These units are, however, characterised by low relationship concentration indices. This is due to the fact that the area of individual geocomplex types is significantly lower than the range of the loess bedrock.
The high values of the first index were also obtained for sand-based units. This indicates a strong relationship between the analysed geocomplexes of this group and the texture of soil cover group 2. Only in the case of two geocomplex types a stronger relationship with other soil texture was observed. The grassland areas with low relief variation are built mostly of type 1 organic soil, while on the areas with deciduous forests soils of type 4 prevail. Due to causes similar as in the case of the loess areas, the values of the relationship concentration factor for the sand-based geocomplexes are very low.
The gypsum-based areas are associated first with soils consisting of heavy loam (5) and second with type 4 loam soil formations. This area was also characterized by the highest value of the relationship concentration factor – 0.37, which, when viewed in absolute terms, is not a high value. It describes relationship concentration between areas with terrain slope 3-6º, utilised as arable land and soils corresponding to the texture type 5.
The highest diversity in soil texture was observed on areas with clay-based bedrock. A strong relationship between the geocomplex types of this group and texture groups 3, 4 and 2 was found. The values of the relationship concentration factor for the two geocomplex types were higher than 0.3.

Relationship between geocomplex type and soil type

In the case of soil types (according to WRB 2007), the highest value of the relationship strength index was observed for the gypsum bedrock. The gypsum area is wholly covered by Mollic Leptosols. The loess-based geocomplexes are also characterised by high soil cover homogeneity. For a considerable majority of these types of areas a strong relationship with Haplic Cambisols was noted. In the remaining cases strong relationships were observed in the case of Colluvic Chernozems and Dystric Chernozems. On the loam areas the most important are Luvisols. For most geocomplexes strong relationships with soil type were observed. The only areas associated with Dystric Cambisols are those covered by deciduous forests. The maximal values of the relationship strength factor for the loam based areas are however lower than in the case of loess-based areas. The values of the relationship concentration index for the gypsum, loess and loam geocomplexes and the soil types are low. The highest values of this index were found for sandy areas with the highest diversity of soil cover types. As far as the relationship strength factor is concerned, a strong relationship was found between the geocomplexes of this group and 6 types of soil. Maximum values of the relationship strength factor for the sand-based geocomplexes are lower than in case of the other three area types.

Summary and conclusions

The results indicate that the analyzed test areas are more homogeneous in terms of soil types than in terms of soil texture. The values of the index of the strength of relationship between soil types and geocomplex types are also higher than in the case of soil texture. On the basis of an analysis preformed for different soil types it can be concluded that delimitation of geocomplexes using the leading factor method appears to yield good results mostly for the gypsum areas. In the case of soil texture, the highest values of the relationship strength factor were obtained for loess-based areas. The values of this index obtained for areas of other soil texture indicate lack of soil cover uniformity within individual unit types. In these cases the assumption that the mosaic of geocomplexes corresponds with the texture of soil leads to a risk of oversimplification.

The obtained values of the relationship concentration factor, except for single geocomplex types, are low. This indicates that within the analyzed areas, the assumed delimitation criteria for geocomplexes do not correspond with the type and texture of soil. In most cases obtaining higher values of the relationship concentration factor would require other, probably more detailed criteria of units delimitation and hence performing analysis on a larger scale.

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Cartographic materials:

Digital elevation model

Corine Land Cover 2000

Soil-agricultural map of the Pińczów area, scale 1:25 000

Soil-habitat map created by the Pińczów Forest Division, scale 1:50 00, made available by RDLP in Radom

Hydrographic map of Poland, scale1:5000, www.kzgw.gov.pl

Detailed Geological Map of Poland, sheets 916, 917, 883, 884, scale 1:50 000