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Spatial peculiarities of Lithuania's soil cover structure in the landscape context

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A general theory of soil science is presented in this article. The conception of soil cover as an integral body having an original spatial structure is developed, and a new method of this structure cognition is presented.

The research methodology is based on a complex outlook employing integrally the GIS analysis, cartographic and logic methods. A territorial unit of the statistical grid is suggested as a foothold in the methodology of soil cover structure analysis. Due to the scale and particularity of the map under consideration, a statistical grid of 2 × 2 km was chosen.

The soil cover structure is considered as a spatial dispersion of soil cover diversity and contrast features, which determine its complexity and structurality expressed in points, establishing them on evaluating the spatial dispersion of the cover areal and linear elements.

The spatial variety of the grain-size composition of a territory has the greatest influence on the degree of soil cover diversity, while the degree of cover contrast depends on the territorial peculiarities of soil pH.

A distinctly higher complexity of soil cover is characteristic of uplands rather than of lowlands, as well as of genetically heterogeneous territories of the surface rather than of homogeneous ones. The soil cover structurality types in which diversity is more pronounced are more characteristic of uplands (except the Medininkai upland) than of plains (except sandy plains). Meanwhile, the cover types where contrast is more evident or territorial structurality is low are more characteristic of plains and deposits of a minor grain-size composition as well as of territories affected by periglacial weathering.

Key words: soil cover structure, diversity, contrast, complexity, structurality, landscape

INTRODUCTION

A slowdown of the development of theoretical fundamentals has been felt in soil science in the last decades, the present theories and conceptions being heavily evolved and the new ones hardly established (Горячкин, 2005). This scientific trend is known as practical rather than theoretical, therefore, most of its works are orientated to solving practical problems associated with the economical utilization of soil as well as with its ecological problems rather than to the development of the fundamental theory of soil science – what is essential to this science as such. Systematic and conceptual geographical ideas are lacking in the theory of soil science.

It is very topical to develop a general theory of soil science, which allows it to integrate into the other scientific branches as well as to the urgent problems of the use of natural resources in the present time of overall integration and modernization of science. One of such trends is a further formation of the conception of soil cover as an integral body having an individual spatial structure, and a search of the ways to study the soil cover. It is relevant not only to the development of the theory of soil science, also for applying its knowledge to the cognition of a landscape structure, functioning and development, as well as to solving land management problems.

The existing single works related to soil cover research are scattered in time as well as throughout individual soil schools. S. V. Goriachkin (Горячкин, 2005) pays attention to this problem, stating that less and less attention is given to the development of the conception of soil cover structure, the earlier created theories being developed heavily and the new ones not being created.

The formation of the conception of soil cover structure and the search of new research methods have become a necessity for exploring and understanding the regularities of soil cover spatial structure. Practically, a solid and integral conception of soil cover and, moreover, of its structure practically does not exist. Only single ideas in the works of individual authors (Фридланд, 1965, 1972) where they express their opinion about what is considered to be soil cover and its structure may be found. No due attention has been paid to the methodological research of soil cover or to its spatial structure analysis in the latter decades.

Because of the fact that there is no geographical conception of soil cover structure, the format of related works is

episodic, the conception of soil cover and its structure in the context of landscape remains undeveloped and its role is underestimated.

Soil cover researches in most cases have narrowed to the analysis of the spatial distribution regularities of different soils which comprise the cover, and little attention is paid to the role of soil cover in the process of landscape formation and to the research of cover structure.

METHODS

The research methodology is based on a complex outlook employing integrally the GIS analysis, cartographic and logic methods. Using together the methods of induction and the GIS analysis, cartographic information and information from the geographic data base, as well as the conception of soil cover structure are merged into one whole. Their territorial and statistical analysis allows revealing the regularities of territorial expression of the parameters named in the conception of soil cover structure.

It is necessary to select different statistical grids (territorial units) in different scales and stages of analysis (Fig. 1). A territorial unit of the statistical grid is suggested as a foothold in the methodology of soil cover structure analysis. It is a formal and the smallest territorial research unit which involves calculation of the values of soil cover structure characteristics (contrast, diversity, complexity and structurality). Due to the scale and particularity of the map under consideration, the statistical grids 2 × 2 km in size were chosen, which are merged into the typological territorial cover units at the later stage of analysis.

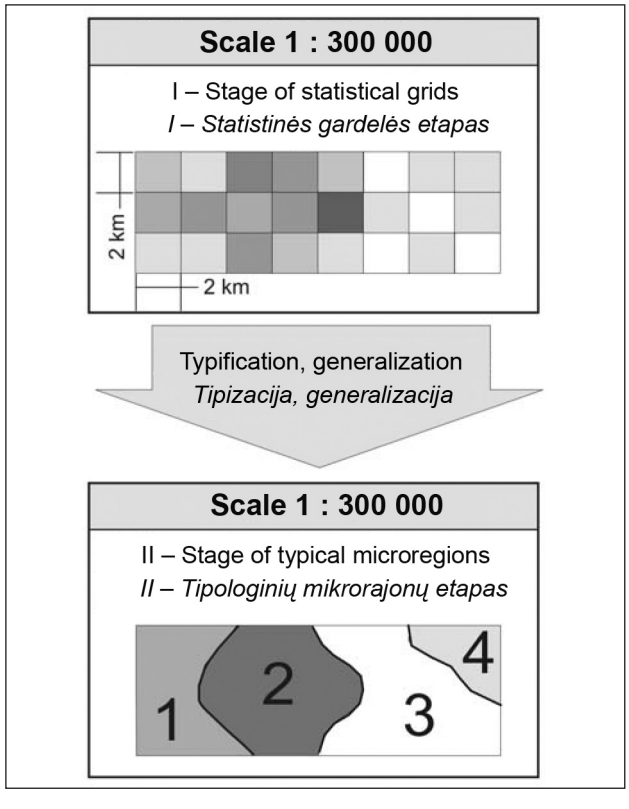

Fig. 1. Application of the statistical grid method

Morphological parameters of soil cover

Four basic characteristics describing the structure of soil cover are highlighted in the process of systematic complex analysis: diversity, contrast, complexity, structurality.

Diversity is a number of soil cover contours differing in concrete properties in a territorial unit (statistical grid) in point expression. The diversity of a soil cover grain-size composition, types of watering, wetness, pH and the depth of calcareous horizon stratification are calculated. The point of diversity gives premises to decide on the variety of the natural conditions, geoecologic potential and invariability of a territory.

Contrast is a contrast index of neighboring soil cover contours in a territorial unit (statistical grid), which is established according to the quality scale of a concrete property and expressed in points. The contrast of a soil cover grain-size composition, types of watering, wetness, pH and the depth of calcareous horizon stratification are calculated. This reveals the geoecologic potential created by contours and the activity of a zone of contours interaction (ecoton) in the process of geochemical barrier formation.

Complexity is a sum of soil cover diversity and contrast points in a territorial unit (statistical grid). Complexity shows the degree of soil cover structure expression. On the one hand, complexity reflects the genetic variety of a territory, on the other – the variety of soil formation processes and their expression degree. This parameter gives the general image of soil cover structure and reflects the general peculiarities of soil cover spatial structure.

Structurality is a difference between soil cover diversity and contrast points in a territorial unit (statistical grid). It shows the genetic dissimilarity of soil cover structure.

A conception of soil cover structure

E. A. Dmitriev (Дмитриев, 1986) has developed and generalized philosophically V. M. Fridland's ideas. He confirmed that the description of the characteristics of soil type profiles cannot figure in a soil cover conception. Their lateral relations must be highlighted here, i. e. *soil cover is considered as spatial structural relations among three-dimensional territorial units of soil types, which compile the cover.*

In Lithuania, research into soil cover structure was carried out by J. Juodis (Йодис, 1967, 1969). He gives the conception of soil cover structure which *comprises the distribution of separate soil components (grain-size composition, carbonate content, water content and the like) in space, the nature of their distribution and interrelation* (Juodis, 2001).

Due to the fact that the conception of soil cover structure is very broad and not final, it is narrowed and concretized in this paper. Therefore, *soil cover structure (in a narrow sense) will be further considered as a spatial dispersion of soil cover diversity and contrast features as well as their interrelation, expressed in points establishing them, having evaluated respectively the spatial dispersion of the cover's areal (the area of a typological unit of a soil level) and linear (edges of contours of a typological unit with the properties of an appropriate soil level) morphometrical elements.*

The conception of soil cover structure used in the paper is based on the assumption, which was also acknowledged by G. A. Malandin (Маландин, 1936), that the dependence

between diversity and contrast should be not necessarily direct and linear. Referring to this assumption, it becomes clear that, if genetically close soils interbond, their number causes a high diversity in a concrete territory, but a low contrast at the same time. Meanwhile, a small number of genetically different soil types falling into a territorial unit under consideration determines a low diversity but a very high contrast.

RESULTS

Diversity of soil cover

Not all the components of soil cover have an equally high influence on soil cover diversity (Fig. 2). Peculiarities of soil cover territorial dispersion of grain-size composition and of the depth of calcareous horizon stratification have the greatest influence on the diversity. A correlation of these two soil cover components with the average significances of soil cover diversity is the strongest.

The following peculiarities of territorial expression are characteristic of the general soil cover diversity in Lithuania:

1. The general structure of soil cover diversity repeats the main orographic features of Lithuania's surface, therefore, it is related to the surface genesis.

2. A much higher diversity is characteristic of the soil cover of hilly morainic uplands rather than of plains where soil cover of low diversity prevails.

3. Morainic uplands differ from lowlands of various types in the structure of grain-size deposits and morphometric surface which also is reflected in the spatial structure of soil cover diversity.

4. Epigenetic re-formation of a territory (fluvial, eolian, periglacial) plays an important role in the process of soil cover spatial (territorial) structure formation. It causes formation of the peculiarities of soil cover local diversity of a territorial structure.

Contrast of soil cover

In comparison with the general soil cover diversity where the cover type of average diversity occupies the bulk of a territory (27.70%), the type of general contrast receives only 20.02%. Meanwhile, in comparison with the diversity where the biggest part of a territory covers the categories from very uniform to average diverse, territories of average contrast decrease; however, there is an increase in less and more contrast territories. This means that more distinct and not so territorially even differences are characteristic of soil cover contrast rather than of diversity. A few general territorial peculiarities show up:

1. The genesis of a territory largely determines the formation of a more or less contrast soil cover via surface relief and the grain-size composition of deposits.

2. The mono- or polygeneticality of a territory, which determine the peculiarities of the territorial dispersion of dominating deposits, their variety of grain-size composition and the degree of intercontrast, also, determine the further trend of soil cover structure development.

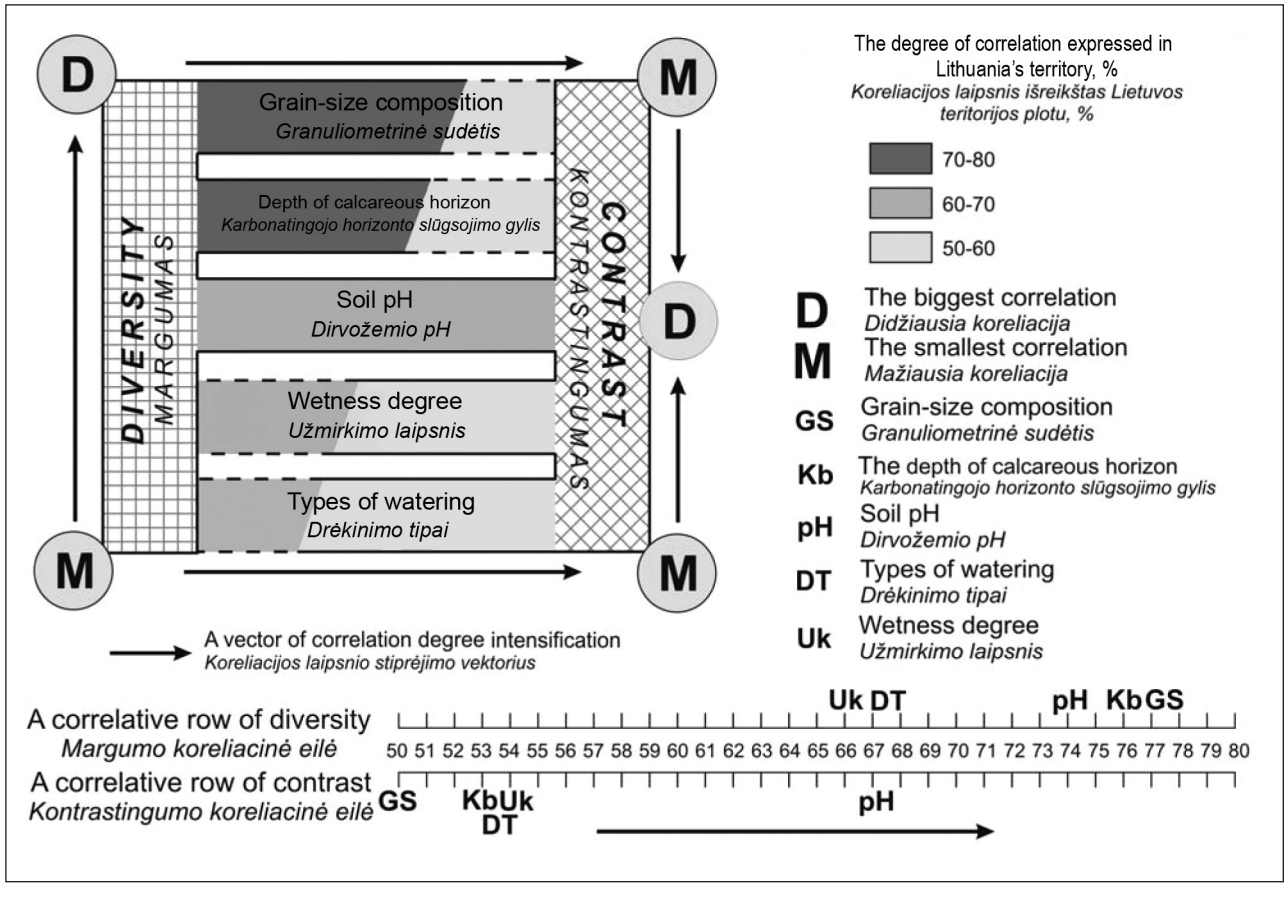

Fig. 2. Correlation of soil cover diversity and contrast

3. The age of a territory and the depth of calcareous horizon strongly affect changes in the territorial structure and expression of soil cover contrast. A smaller contrast of soil cover is characteristic of young carbonate or older non-carbonate and more homogeneous deposits rather than of old and carbonate deposits distinguished for a higher territorial diversity.

4. An epigenetic factor impacting a territory decreases the soil cover contrast, if it is directed at a reduction of differences of deposits or surface relief (periglacial weathering), and increases the contrast if it varies the grain-size and genetic composition of deposits and increases surface decomposition of (fluvial processes).

Essential features of the territorial structure of soil cover contrast show up while comparing it in the context of morainic uplands and lowlands of various genesis.

Territorial regularities of soil cover complexity and structurality

As a territorial analysis of soil cover diversity and contrast showed, there is no single prevailing type of soil cover structure neither according to diversity nor to contrast in Lithuania's territory. The types of a simple (27.92%), average complex (24.26%) and complex (22.52%) cover should be regarded as the prevailing types of soil cover complexity. The types of soil cover complexity prevail in the hilly and wavy Lithuania's surfaces, beginning with those medium complex and up to very complex ones. Meanwhile, simple and very simple soil cover types prevail in plains.

Territorial regularities of soil cover complexity correlate with the main orographic and genetic peculiarities of Lithuania's surface in the presented in map Fig. 3. Therefore, it is purposeful to refer to the main types of Lithuania's landscape: morainic, glacial lacustrine, archaic alluvial, outwash plain, seacoast and deltaic plains; hilly laky and hilly gully morainal uplands; river valleys. Lithuania's uplands, which most often have a medium complex, complex and very complex soil cover, show the highest soil cover complexity.

The variety of deposits as well as complex epigenetic processes predetermined a complex and very complex soil cover structure of the Medininkai, Buivydžiai and Švenčionys uplands. Meanwhile, a very heterogeneous structure of soil cover is characteristic of the strip of the Baltic uplands (a hilly morainic laky landscape). The upland's southeastern margin, mottled with poor selected outwash plain deposits, distinguishes for its soil cover complexity. Inclusions of these outwash plains impact the formation of this compact belt which has a medium complex and complex soil cover structure.

The area of the Ignalina lake district differs from the general context of uplands by its relatively low structurality. The smoothness of lithogenic conditions of the morainic ridges which form the central part of the upland predetermines not only a relatively small diversity of soil formation conditions, but also their weak intercontrast; thus, a medium complex and even simple in its spatial structure soil cover is spread in separate patches of this part of the uplands.

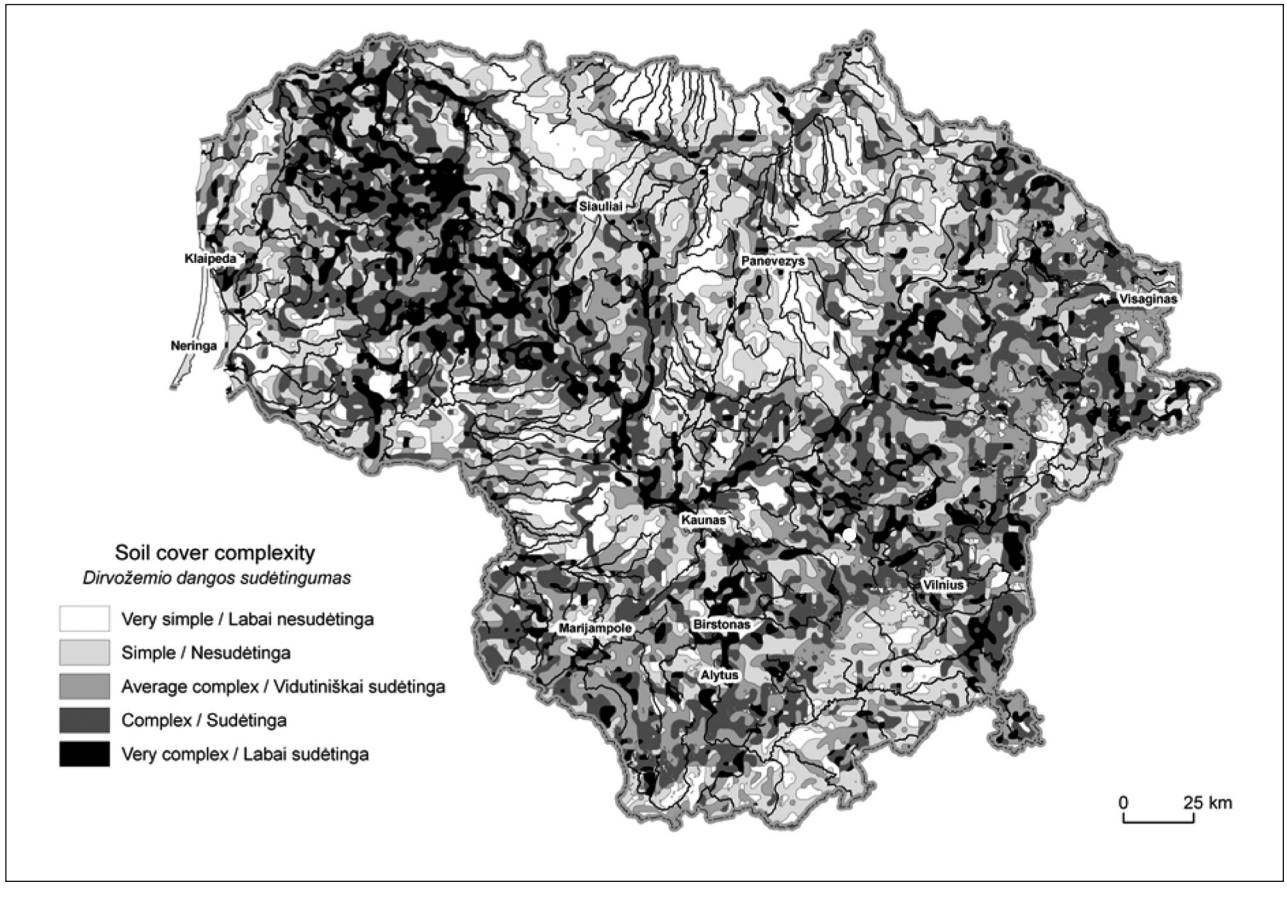

Fig. 3. A map of soil cover complexity

Unlike at the eastern outwash plain margin, at the western margin of the uplands the soil cover complexity is caused by inclusions of not only fluvioglacial, but also of glacial lacustrine deposits. Also, separate areas of a complex cover have been formed by the territorial structure of old-time alluvial deltas (the Šventoji, the Virinta) and valleys of bigger rivers.

The Samogitian upland differs from the general context of the upland soil cover complex by its general cover complexity. The general spatial structure of its cover is caused by a mosaic of morainic solids and linguiform depressions.

A variety of lowlands' soil cover structure is explained by their different genetic nature. There are morainic, glacial lacustrine, archaic alluvial, outwash plain, seacoast and deltaic plain landscapes. Outwash plain, glacial lacustrine and morainic plains show the greatest differences in soil cover structure complexity.

The prevailing simple soil cover structure is characteristic of the outwash plain landscape type (the Southeastern sandy plain). This is due to the homogeneous and non-contrasting, according to the grain-size composition, deposits formed under the influence of fluvioglacial flows. The cover complexity is higher only in those places where morainic formations of the Grūda or the Žiogeliai stages rise in separate islands to the surface, or swamps form in lower places. The structure of soil cover surface becomes simple in the places where landmasses of continental dunes cover the surface. Certain glacial lacustrine lowlands (the Neris reaches, the Verknė–Peršekė and the Jiesia) show the largest complexity of soil cover spatial structure. The polygenetic origin of these lowlands determines such a complicated structure matching the cover structure of uplands.

The grand glacial lacustrine lowlands of Lithuania (Užnemunė, Karšuva) are notable for the structure of soil cover complexity which is close to morainic plains. Such a similarity is caused by the fact that rather homogeneous and little contrasting glacial lacustrine formations prevail here. The cover complexity increases only in the places where these formations are covered by sand of old-time alluvial deltas, carved with river valleys or where single morainic hills rise to the surface.

A heterogeneous structure of soil cover is characteristic also of morainic lowlands. The Žemgala lowland is notable for the highest homogeneity of soil cover and the lowest structure complexity. Meanwhile, the cover structure of the Central Lithuanian lowland is highly variegated and varies from simple to complex or very complex.

The territorial differences of soil cover complexity allow stating that territorial regularities are characteristic of soil cover diversity and contrast. Referring to this statement, the main types of soil cover structurality (Fig. 4) have been distinguished, and their formation being caused by several basic factors:

1. The componential (phasic) nature of the soil body and unequal regularities of territorial expression characteristic of its separate components.

2. The morphogenetic peculiarities and regularities of territory formation.

3. Regional and local epigenetic factors and the regularities of their progress fluctuation in time and space.

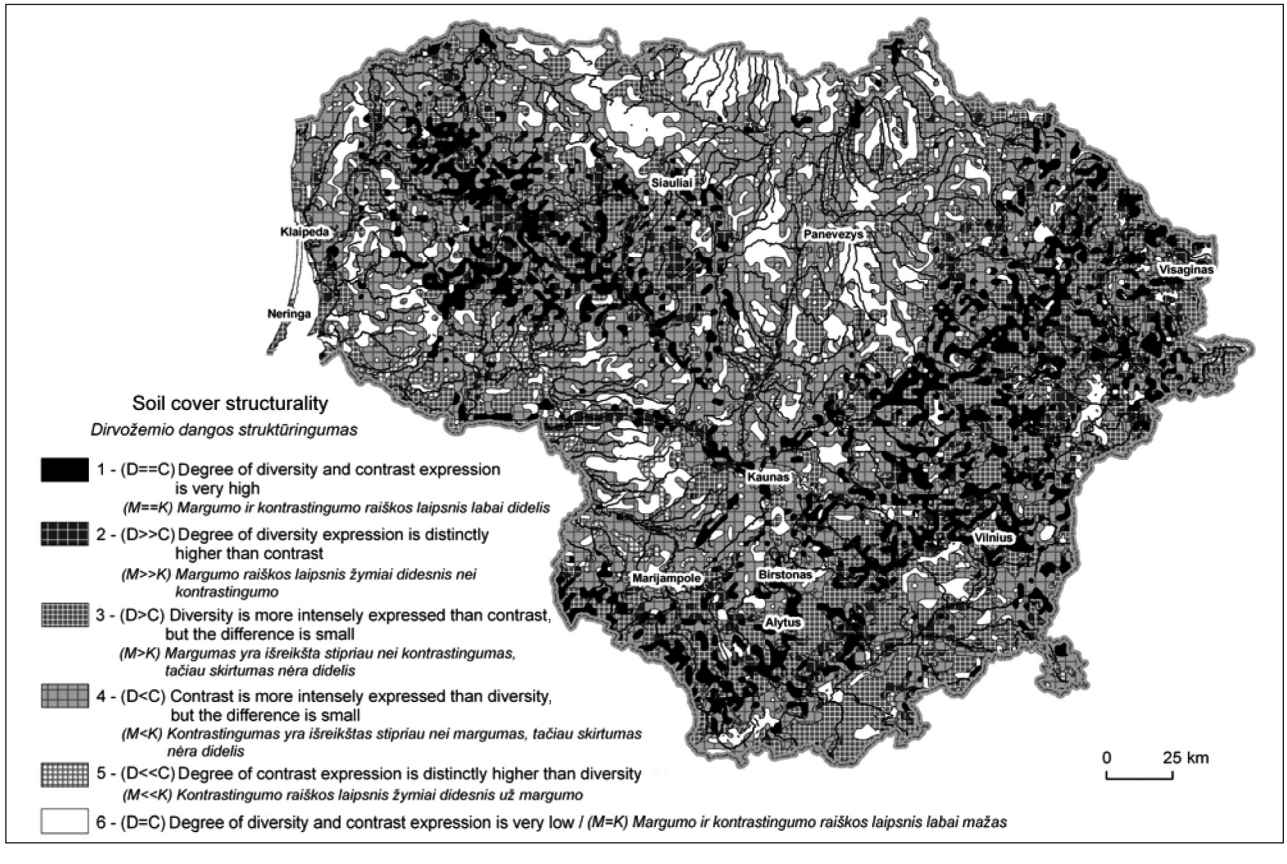

Fig. 4. A map of soil cover structurality

4. The depth of the calcareous horizon and the time interval when the processes of soil formation are in progress.

The first type (high general structurality – ↑ D = C ↑). From the geoecological point of view, these territories should be considered as the most valuable because they show a great variety of ecological and soil formation conditions. As a rule, the spread of this soil cover structurality type should be associated with the spread of morainic massifs which comprise uplands.

Although this cover type is common to the both Baltic and Samogitian uplands, the concentration is higher in the latter one. This is caused by its more complex structure of soil cover. Also, this type of cover structurality is found in ridges splitting the Central Lithuanian lowlands into separate plots. Areas of this type occupy 12.38% of Lithuania's territory.

The second type (high diversity and low contrast – ↑ D >> C ↓) is also more characteristic of uplands than of lowlands. The dispersion of this type of territories is lower by half (5.55%) than of the first ones, and the greatest part of them is converged in the outwash plain belt of the Baltic uplands and in the lake zone of the Aukštaitija uplands, also, in the morainic massifs of the Samogitian uplands and in river valley plots (the Nemunas, the Merkys, the Šventoji), where a great variety but a low contrast of soil-forming deposits is present.

The third type (diversity is slightly more pronounced than contrast – ↑ D > C ↓) is found in uplands and lowlands. Referring to the spatial dispersion of this soil cover structurality type, it is possible to highlight the essential genetic differences of uplands. The soil cover of this type is most common in the central part of the Baltic uplands which are notable for a higher genetic surface homogeneity than its margins.

The areas of this type are very few in the Samogitian upland, and they appear mainly in the East Samogitian plateau, i. e. in morainic massifs with a coarser grain-size composition of deposits. This soil cover structurality type is one of the dominant types in Lithuania's territory and occupies 26.29% of the surface.

The forth type (contrast is slightly more pronounced than diversity – ↓ D < C ↑) is characteristic of the Medininkai upland of the penult glaciation phase (Middle Pleistocene). This soil cover type is most common and covers 38.18% of Lithuania's territory. The prevalence of this type of cover in the Medininkai upland confirms the above idea that the age of the deposits that compose soil and the depth of the calcareous horizon have a great impact on the territorial expression of soil cover diversity and contrast.

The soil cover structurality type is also characteristic of the Samogitian upland, where morainic and glacial lacustrine lowlands make territorial complexes with the other types of cover.

The fifth type (high contrast and low diversity – ↓ D << C ↑) covers the least of Lithuania's territory (2.39%). Plots of this cover type are characteristic of the territories of morainic and clayey plains with deposits of a different genesis and very different grain-size composition.

In addition to the dominating fourth type of cover in the Central Lithuanian, Užnemunė, Karšuva and Maritime lowlands, a great part of surface is taken by *the sixth type* (low diversity and low contrast – ↓ D = C ↓) which is notable for a very small degree of both diversity and contrast. Also, separate plots of soil cover with the third type of cover (↑ D > C ↓) distinguish in the Central Lithuanian lowland.

A polynomial spatial structure of soil structurality types, having been formed in lowlands, shows that a variety of soil formation conditions plays an important role here, and that variety reveals itself via contrast.

To sum it up, the first three types of cover structurality are more characteristic of uplands (except the Medininkai upland) rather than of lowlands (except sandy plots of the Dainava and other lowlands). Meanwhile, the rest three cover types in which contrast is more pronounced and a generally low structure is common, are more characteristic of plains and deposits of a finer grain-size composition, as well as of the territories affected by periglacial weathering.

CONCLUSIONS

1. The application of the statistical grid method in soil cover researches allows to dissociate from the present territorial structure determined by soil type areas, and to analyse its individual features separately, forming qualitatively different areas of soil cover structure and highlighting the spatial soil cover structure.

2. The spatial variety of a soil grain-size composition exerts the strongest influence on the degree of soil cover diversity, and the territorial peculiarities of soil pH determine the degree of cover contrast.

3. A distinctly higher complexity of soil cover is more characteristic of uplands than of lowlands, as well as of genetically heterogeneous territories of surface rather than of homogeneous ones.

4. The soil cover structurality types in which diversity is more pronounced are more characteristic of uplands (except the Medininkai upland) than of plains (except sandy plots of the Dainava and other lowlands). Meanwhile, the cover types where contrast is more pronounced or territorial structurality is low are more characteristic of plains and of finer grain-size deposits as well as of territories affected by periglacial weathering.

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LIETUVOS DIRVOŽEMIO DANGOS STRUKTŪROS ERDVINIAI YPATUMAI KRAŠTOVAIZDŽIO KONTEKSTE

S a n t r a u k a

Mokslo integracijos bei modernizacijos laikais yra labai aktualu plėtoti bendrąją dirvožemio mokslo teoriją. Viena krypčių – dirvožemio dangos, kaip vientiso, savita erdvine struktūra pasižyminčio, kūno koncepcijos tolesnis formavimas bei jo struktūros pažinimo būdų paieška. Tai aktualu ne tik pačios dirvožemio mokslo teorijos vystymui, bet ir jos žinių panaudojimui kraštovaizdžio struktūrai bei funkcionavimui ir vystymuisi pažinti, taip pat kraštotvarkos uždaviniams spręsti.

Tyrimo metodika remiasi kompleksiniu požiūriu, integruotai taikant GIS analizės, kartografinius bei loginius metodus. Tai leidžia išryškinti teritorinius, dirvožemio dangos struktūros rodiklių raiškos dėsningumus.

Kaip atspirties tašką, dirvožemio dangos struktūros analizės metodikoje siūloma naudoti statistinės gardelės teritorinį vienetą. Atsižvelgiant į analizuojamo žemėlapio mastelį bei detalumą pasirinkta 2 × 2 km statistinė gardelė.

Dirvožemio dangos struktūra suprantama kaip dirvožemio dangos margumo bei kontrastingumo savybių erdvinė sklaida, išreikšta balais juos nustatant, įvertinus plotinių bei linijinių dangos elementų erdvinę sklaidą.

Taip pat dirvožemio dangos struktūrą atspindi bendrasis jos *sudėtingumas ir struktūringumas.*

Teritorijos granuliometrinės sudėties erdvinė įvairovė turi didžiausią įtaką dirvožemio dangos margumui, o dirvožemio pH teritoriniai ypatumai – dangos kontrastingumo laipsniui.

Gerokai sudėtingesnė dirvožemio danga yra būdinga aukštumoms nei žemumoms, taip pat genetiškai nevienalytėms, nei vienalytėms teritorijoms.

Dirvožemio dangos struktūringumo tipai, kuriuose išreikštesnis margumas, yra būdingesni aukštumoms (išskyrus Medininkų), nei lygumoms (išskyrus smėlingąsias lygumas). Tuo tarpu dangos tipai, kuriuose išreikštesnis kontrastingumas arba būdingas menkas teritorinis struktūringumas, yra būdingesni lygumoms bei smulkesnės granuliometrinės sudėties nuoguloms, taip pat teritorijoms, kurios yra paveiktos periglacialinio dūlėjimo.

Raktažodžiai: dirvožemio dangos struktūra, margumas, kontrastingumas, sudėtingumas, struktūringumas, kraštovaizdis