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MORPHOLOGY OF LANDSCAPE BIOTA TERRITORIAL STRUCTURE (ON THE EXAMPLE OF LITHUANIAN TERRITORY)

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Introduction

One of the most relevant problems of modern times is the fragmentation of living organism habitats under the impact of human activity, which is directly influencing the decline of the landscape biotic[1] component variety both on the regional and on the global levels (Saunders and others, 1991). On the other hand, total suspension of human activity affects the formation of landscape biota territorial structure in the level of degradation, which is often perceived as the disappearance of landscape and biological diversity.

All natural protected areas and other ecologically valuable or relatively natural areas which underpin the general landscape stability in Lithuania are linked into a land management system of geoecological compensation zones – a Nature Frame, the idea of which was raised and approved two decades ago – in the year 1983. Since that time Lithuanian landscape has been transformed by political and economic changes. The "kolkhoz" system collapsed thirteen years ago – the vast stretches of land were sub–divided and the ecological mosaic thus increased (considerable number of works analyzing the changes of land use were written: J. Milius, F. Kavoliutė, G. Ribokas, G. Godienė and others). Still a part of meadows and pastures, infertile but very valuable in the view of landscape biological diversity, was abandoned; scrubs, bushes and trees of little value grew over it. In the same way a total restriction of human economic activities near the water resources has contributed to the formation of Lithuanian zonal-type communities of broad-leaved–coniferous forests. They accelerate the evolution (oligotrophy–eutrophy) processes of the water habitats, important in the view of landscape diversity. All these factors contributed to the territorial changes of landscape biota.

Consequently, if we want to keep the balance in our environment and to organize sustainable development of landscape, we have to know the contemporary state of Lithuanian landscape biostructure. This requires quantitative and qualitative assessment of landscape biota territorial structure, which allows revealing the consistent patterns of spatial distribution of structural elements and discerning the most characteristic territorial complexes, distinguished by different physiognomy, and vertical and horizontal structure of biotic cover.

A lot of works of Lithuanian botanists, zoologists, ecologists are devoted to the research of biota structure as the living organism communities with species differentiated according to the niches (J. Balevičienė, V. Rašomavičius, J. Naujalis, Z. Sinkevičienė, D. Patalauskaitė, J. Tupčiauskaitė, Ž. Lazdauskaitė, M. Žalakevičius, P. Kurlavičius, L. Balčiauskas, R. Baleišis, P. Bluzma, A. Ulevičius, L. Raudonikis). However, there is lack of research works that view biota from the point of landscape morphology and there is no geographical model of landscape biota territorial structure in the Lithuanian landscape science.

[1] The term *biotic* in this work is used, as an antonym to the concept *abiotic*, which is for conveyence of natural characteristics of investigated landscape components – are they alive or not alive.

Therefore, the main aim of this work is to reveal the current Lithuanian landscape biota territorial structure as well as the consistent patterns of spatial distribution of this structural territorial complexes, having in mind that one of the main goals (Lietuvos..., 2004) of the landscape policy of the Republic of Lithuania is: "to determine the structural diversity of our country."

1. The Concept of Landscape Biota Territorial Structure

The term *landscape biota* is perceived as a sum of biocomponents (vegetation, fungi and animals) in this work. They influence the particularities of landscape morphology. All living organisms as an integral part of ecosystems are understood by this term in the classical concept of ecosystem (Tansley, 1935; Одум, 1986). Nowadays ecosystem is treated as cartographical object in the landscape ecology science in North America and Western Europe (Forman, Godron, 1981; Godron, Forman 1983; Forman, 1995). According to this concept ecosystems (forest, meadow etc.) are referred to as *landscape biota territorial structure elements (BTSE)* in this work. The organization of ecosystems on the Earth surface forms ***the landscape biota territorial structure*** *(BTS)*.

Broad-leaved–coniferous forests represent the main zonal type of vegetation in Lithuania (*Ass. Querco-Piceetum*). Thus, the natural change trends of the biotic cover of our country are related with succession and the formation of stable climax communities – forests. There are also natural landscape BTSE – wetlands and alluvial meadows in Lithuania. Therefore the first feature, according to which the types of landscape biota territorial structure elements are classified is their **physiognomy**: *subnatural* (the initial succession is prevailing) or *anthropogenic* (the natural succession is interrupted by the human activities) (Table 1). Actually, since the human activity is not a constant factor, the scrub and trees growth can be observed in the extensively used territories and the *renaturalized* habitats are formed (the secondary succession is taking place).

The feature, which allows discerning the second classification stage (BTSE classes), is **the vertical arrangement** of the habitat constituents ***(their height and form)*** that is characteristic of all terraneous ecosystems: forest, meadow, wetland and others. For the urbanized territories a specific vertical structure of biocenosis is typical, but the more detailed research scale must be used for its analysis to compare the one used in this work (M 1:200 000). Thus the urboecosystems will not be analysed in this work.

Horizontal mosaic is the feature, according to which the landscape biota territorial structure elements are classified in the third stage (BTSE subclasses). All ecosystems can be treated as areal and linear elements. According to their form, distribution and the area, all surface of the land consists of the matrix, patches and migrational corridors. American and French scientists R.T. Forman and M. Godron (Forman, Godron, 1981, 1986) were the first who proposed these terms. These three territorial structural element types of biota are visually discerned on the map: *1. Matrix* is a BTSE characterized by its continuity and maximal unity; *2. Patches* are the areal, small and chaotically distributed different from the matrix BTSE; *3. Corridors* are the linear elements that connect other BTSE. Water flow ecosystems that are discerned with the scale 1: 200 000 are considered as corridors in this work.

2. Research Methods

Various methods were used in this work: logical methods (analysis of facts, formulation of concepts, classification, induction, hypothesis and analogy), mathematical methods (factor analysis, calculation of landscape indices) cartographical methods (analysis and preparation of maps), and regionalization methodological principles.

Table 1. Classification of landscape biota territorial structure elements (BTSE).

Height		Physiognomy					
		Subnatural		Anthropogenic		Renaturalized	
		BTSE	Form characteristics	BTSE	Form characteristics	BTSE	Form characteristics
High		Forests	High woody plants	Urbo complexes	Complexes of territories with buildings of various height with their own infrastructure		
Average		Wetlands	Low herbaceous plants, woody bushes, single trees	Agro complexes	Small height cultures with the patches of woody vegetation (for example, fruit tree gardens)	Shrub and/or grass vegetation	Low herbaceous plants, woody bushes
Small	Ecosystems with continuous vegetation cover	Meadows	Low herbaceous plans	Pastures	Low herbaceous plants		
Small	Ecosystems with discontinuous vegetation cover	Sands	Land with sparse embryonic plant cover or completely without it	Ruderal communities	Land with sparse herbaceous cover, but mostly without it		
Underwater layers		Lakes, rivers, the sea, Curronian lagoon	Compact volume objects or linear prolonged volume objects located on depressed surfaces, lower places.	Ponds, canalized river beads	Compact volume objects or linear prolonged volume objects located on depressed surfaces, lower places.		

Based on logical analysis and synthesis, the research works on the subject of this work in Lithuania and abroad were analysed, the landscape biota territorial structure and its territorial unit concepts were formulated.

Mathematical landscape analysis in the view of biotic component was performed employing the following digitalized cartographical material:

1) CORINE–2000 Lithuanian Earth surface digital database (© Lithuanian Environmental Protection Agency under the Ministry of Environment; European Environmental Agency, 2005) was used for the analysis of landscape biota territorial structure element (BTSE) spatial distribution and for analytical landscape indices calculation.

2) Lithuanian geomorphologic map (1: 200 000; © Lithuanian Geological Survey, 2002); LR digital soil database (Lithuanian territory's 1:300000 digital soil map © National Land Service under the Ministry of Agriculture; © State Land Survey Institute, 1999); Lithuanian landscape morphologic map at a scale 1: 400 000 (© Ministry of Environment; © JSC Urbanistika, 2001); Lithuanian average annual precipitation quantity map (1: 1 750 000; © Centre for Cartography of Vilnius University, 2004); Lithuanian vegetation map (1:1 000 000; Brundza and others, 1981) was used for the evaluation of abiotic and biotic landscape components correlation (*factor analysis*) as well as for the discernment of landscape biota territorial structure complexes – *geobiocomplexes*.

3) GDB200 (© GIS-CENTRAS, 1993–1999) was used as the geographical basis for typological and individual regionalizations of Lithuanian territory.

The subject of *factor analysis* was the typological unit of potential vegetation based on Lithuanian vegetation map (Brundza, Pakalnis, Budriūnas, 1981). The variables examined are abiotical landscape components (parent materials, soils, the relief and the air), expressed in % points and relative distribution frequency (%) in every potential vegetation typological unit. The analysis of potential vegetation typological units was performed according to the classical factor analysis model (Čekanavičius, Murauskas, 2002, Девис, Радионов, 1977, Харман, 1972) by using a method of main components.

For making the interpretation of the acquired factors easier, the two initial variable characteristics were taken into account. They can determine some correlation tendency distortions – it is a ratio of every variable area in percents and its relative frequency. There are 4 types of factor interpretations (Table 2). The factor was named following the characteristics of the variables that comprise it.

Table 2. Types of factor interpretation according the ratio of variables area (%) and relative frequency in potential vegetation typological unit

Relative frequency, %	**Area, %**	
	≥20	**<20**
≥20	Main factors	Specification factors
<20	Supplementary factors	Controversial factors

Determination of territorial units (called geobiocomplexes) was based on the concept that all edaphic, topographic, climatic and anthropogenic factors are the basis to determine the type of irrigation of a territory, the amount of water infiltration, nutrient balance and the degree of inartificiality. This basis connects spatially close BTSE that are linked by the special energy and nutrient ties into one *geobiocomplex*. Inside of each geobiocomplex a special combination of BTSE develops.

Regionalization methodology was based on the logical rules of the set division (Pečkaitis, 2004). Traditional scale 1: 2 000 000 commonly used in natural geography was chosen for the individual landscape regionalization according to the biota territorial structure features.

Scale used – 1: 200 000. Software used: ArcGIS v.9.0 Desktop, ArcGIS v.9.0 Workstation, ArcView 3.2[a] programs and their extensions *Spatial analyst, vLATE1.1, Fragstats for Arcview, FragstatsArc.* With *SPSS 10.0 for Windows* program factor analysis was performed.

3. Research Results and Disscusion

Landscape biota territorial structure element distribution analysis. The human being and its impact upon our zonal vegetation type – forests is the main accelerator of contemporary biota territorial structure (BTS) formation. Landscape indices were used in order to highlight the different BTSE characteristics and analyze their distribution in the territory of Lithuania. There are the distribution characteristics of BTSE physiognomy, vertical and horizontal structure indices analysed in this work.

BTS physiognomy is determined and the territories of different anthropogenic impact are discerned, according to the whole range of forest spatial distribution metrics – forest patch size (a part of forest patches up to 2000 ha in the territory), geometric form (forest patch shape index) and connection (mean neighbourhood distance).

The average distance a_{vid} among forest patches was calculated for all Lithuania's territory (CORINE-2000 LŽD (© Lithuanian Environmental Protection Agency; European Environment Protection Agency) using the *mean neighbourhood distance* index. The average distance among all forest patches in Lithuania is 331,80 m. According to this value all Lithuanian forests were divided into separate clusters, where they are closer to each other than the average distance a_{vid}.

With reference to this, 924 areas of forests clusters were formed. Forest patches up to 2000 ha in each area of forest clusters are evaluated (from ~20% to ~96%) and show the fragmentation of forest cover. The average values of shape index (from 0,14 to 0,48) show the complexity of forest patch shape. The values of mean neighbourhood distance index (from ~61 m to ~673 m) show the peculiarities of connections between woody complexes. According to this the four types, describing different physiognomy of BTS (anthropogenic, anthropogenized, slightly anthropogenized and subnatural) were discerned (Fig. 1). The highest values of all indices are characteristic to the Central Lithuania Lowland, Baltic Upland, East Žemaičiai Plateau, Kuršas Uplands and Lithuanian coastal zone. The lowest values are typical of East Lithuania and Western Žemaičiai Plateau.

Edge contrast index of all BTSE was used to analyse the BTS vertical structure. The highest magnitude of edge contrast between adjacent BTSE types (>71%) is observed in East Lithuania and West Žemaičiai Plateau. The average contrast (31–70%) is typical to Central Lithuania BTSE (except for Užnemunė territory). The lowest contrast (<30%) – can be found in Aukštaičiai highland western sides, East Žemaičiai Plateau, and Užnemunė Lowland as well as in some parts of Pajūris Lowland BTSE.

The distribution of horizontal structure characteristics was analysed in the similar way. One of the indices is the ratio of BTSE area and number of neighbours. According to this index 7 horizontal structure types were distinguished (Table 3). Two types prevail in Lithuania. The first one is a type of small areas (<500 ha) with small number of neighbours (< 23 neighbours) (~ 44 %), occupying the vast territories in Žemaičiai, Baltic, Ašmena and Švenčioniai Uplands. The second type is characterized by large areas (> 2000 ha) with big number of neighbours (> 123 neighbours) (26 %) and is common to Central Lithuanian Plain, Southeastern sandy plain and West Žemaičiai Plateau.

Horizontal biota structure peculiarities were analysed according to the theory of graphs. The lines separating individual BTSE were treated as edges and their intersections as vertices. The more there are edges that meet in 1 vertex, the bigger is the variety of ecosystems.

Fig. 1. The distribution of biota territorial structure physiognomy types in Lithuania, determined by the values of forest patch size, shape and nearest neighbour indices.

Three BTSE (CORINE 2000 3 level codes are 3.1.3., 2.1.1., 2.4.2., 2.4.3.) intersections prevail in the BTSE network of Lithuania. They are concentrated in the Baltic and Žemaičiai uplands and indicate an average variety of ecosystems. Central Lithuanian Lowland stands out as two BTSE (2.1.1. and 2.4.2.) intersections dominance area and the level of ecosystem variety is the lowest. At the same time four BTSE (2.1.1., 2.4.2., 2.4.3., 3.1.3., 2.3.1.) intersections are scattered throughout all Lithuania and do not form spots of bigger concentration.

Abiotic and biotic landscape component factor analysis results. Common feature of all potential vegetation typological units indicates that all factor types – main (together with the supplementary ones), specification and controversial factors explain approximately equal percent of variable dispersion. It means that all potential vegetation typological units are being formed on the mixed background *(controversial factors).* Therefore the types of potential vegetation influenced by edaphic components *(specification factors)* could be determined on the larger scale. Whereas the main factors (together with the supplementary ones), discerned by landscape component correlations, indicate the main forces, which have the major influence on the formation of the analyzed potential vegetation typological unit.

The climatic climax of south taiga shrubby spruce forests *(All. Piceion abietis*[2]*)* and the edaphic climax of pine forests dominated by green mosses (*All. Dicrano–Pinion)* as well as black-alder forests (*All. Alnion glutinosae, All. Salicion cinereae),* high moors of West Lithuania (*All. Sphagnion magellanici, All. Ledo–Pinion*) and transition moor communities (*All. Betulion pubescentis)* are characterized by the most obvious determinism

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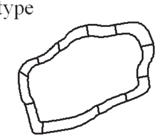
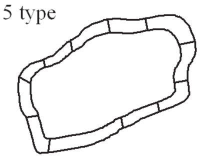
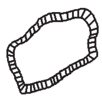
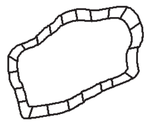
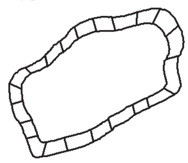
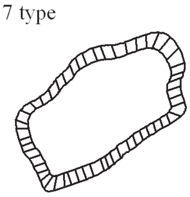
[2] All equivalents of vegetation units according J. Braun–Blanquet (1964) hierarchical synaxon system are taken from Балявичене, 1991; Dierssen, 1996; Matuszkiewicz, 2002; Navasaitis ir kt., 2003.

Table 3. Horizontal structure types based on the ratio of BTSE area (ha) and number of neighbours surrounding 1 BTSE.

	Area, ha		
	Small (0–500 ha)	**Average (500–2000 ha)**	**Big (> 2000 ha)**
Small (up to 23 units)	1 type 	3 type 	5 type 
Average (23–123 units)	2 type 	4 type 	6 type 
Big (> 123 units)	–	–	7 type 

of abiotic landscape components. However, mixed edaphic–topographic–climatic complex of factors characterize the abiotic structure of broad-leaved–spruce forests *(All. Piceion abietis, All. Carpinion betuli, All. Alnion incanae),* broad–leaved forests *(All. Carpinion betuli, Alnion incanae)* as well as alternative communities (*All. Piceion abietis, All. Carpinion betuli, All. Alnion incanae succession and regeneration stages*). Therefore, in order to highlight the differences of potential vegetation in the regional level, the edaphic peculiarities must be taken into consideration.

Specification factors explaining the similarly variable dispersion percentage, as the main ones are mostly associated with edaphic characteristics in each potential vegetation typological unit. Therefore, it is necessary to discern the vegetation types, reflecting the abiotic conditions of the peat, the sand and the valley before the usage of this vegetation map in a larger scale.

The percentage of the controversial factors existing in each potential vegetation typological unit reflects the huge amount of small landscape components and the formation of the potential vegetation typological units on a mixed abiotic base.

Typological regionalization. The typological regionalization is based on the classification of geobiocomplexes by various features: BTS physiognomy, vertical and horizontal structure and edaphic conditions.

Classification of geobiocomplexes *by BTS physiognomy* consists of 3 stages (Table 4). The leading factor of the first level (geobiocomplex type) shows the most general human impact on the vegetation cover of our country and is described by two parameters – percentage of forest cover (%) in the geobiocomplex and the number of forest patches up to 2000 ha in a geobiocomplex.

A class of geobiocomplexes (II level) was defined according to the average distance between forest patches. This feature reflects the living organism dispersion characteristics in the regional level.

A subclass of geobiocomplexes (III level) was defined according to the aspects of the forest patch shape, reflecting the local impact on the living organisms. This is the degree of forest patch shape complexity.

There are 53 subclasses determined in the III level. Their descriptions reflect all the parameters of BTS physiognomy (for example, 4–4–3 means that the forest cover in the geobiocomplex is fragmented, weekly connected, dominated by low complexity forest patch shapes). Separate schemes of geobiocomplex territorial distribution according to the BTS physiognomy parameters are composed in this work.

Table 4. Classification features of geobiocomplexes according to BTS physiognomy.

Fragmentation types				Woodless
1. Not fragmented [1]≥60% [2]0–99%	**2.** Slightly fragmented 20–60% or≥60% 0–90% or 100%	**3.** Fragmented 0–20% or 20–60% 0–99% or 100%	**4.** Strongly fragmented 0–20% 100%	
Connection types				
1. Strong [3]≥0–60 m	**2.** Average ≥60–100 m	**3.** Weak ≥100–300 m	**4.** Very weak ≥300 m	
Complexity types				
1. High [4]≥0–0,2	**2.** Average ≥0,2–0,3	**3.** Low ≥0,3–0,5	**4.** Incomplex ≥0,5	
[1] Percentage of forest cover [2] The share of forest patches up to 2000 ha [3] Average distance to the nearest neighbour, m [4] Shape index				

According to the physiognomy of biota territorial structure (forest patch size, shape and nearest neighbour distance indices, showing the peculiarities of forest cover fragmentation, shape complexity and interconnections) the geobiocomplexes of anthropogenic and anthropogenizated types (fragmented forests with week interconnections and low shape complexity) dominate in Lithuania. Not fragmented forests, dominated by strong interconnections and highest shape complexity – slightly anthropogenizated and subnatural types are typical for all woody territories in Lithuania.

Geobiocomplexes were classified according to ***vertical territorial structure of biota***. The main features used were the height type dominant by the area in the geobiocomplex; the edge contrast index prevalent by the area in the geobiocomplex; the edge contrast index dominant by the number in the geobiocomplex (Table 5).

Table 5. Classification features of geobiocomplexes according vertical territorial structure of biota.

Vertical structure types according the BTSE height			
1. High	**2.** Average height	**3.** Short a) Continuous vegetation cover b) Discontinuous vegetation cover	**4.** Underwater layers
Vertical structure types according to the BTSE edge contrast index			
1. Homogeneous [5]0–30%		**2.** Average homogenuous 31–70%	**3.** Heterogeneous 71–100%
[5] Edge contrast index			

Three levels of geobiocomplex classification by vertical BTS were defined. Each of them has a leading feature: a type (a height type), a class (the value of the edge contrast index dominated by the area in the geobiocomplex) and a subclass (the value of the edge contrast index dominated by the number in the geobiocomplex). 30 subclasses, describing each geobiocomplex by the set of all vertical structure features, were formed. Typological regionalization schemes of Lithuania, according all features mentioned above were composed.

According vertical structure (BTSE height and BTSE edge contrast index) geobiocomplexes with average BTSE height and average BTSE homogeneity are dominant in Lithuania. They are characteristic of the Central Lithuanian Lowland and scattered in the Aukštaičiai, Dzūkai and Žemaičiai uplands. Homogeneous BTSE of average height occupies smaller territories in Lithuania and dominate in the East Žemaičiai Plateau, Kuršas Upland, southern part of Pajūris Lowland and Užnemunė Lowland. Big height and heterogeneous BTSE are dominant in the most forested geobiocomplexes. Nemunas delta and its deltaic valley stand out from all Lithuanian vertical structure, by dominance of low height and homogeneous BTSE.

The following parameters characterize the geobiocomplexes according to *horizontal territorial structure of biota*: 1) the type of all BTSE parts (%) ratio in geobiocomplex (Table 6) ; 2) the type of BTSE size and number of adjacent BTSE ratio, dominated by the area in the geobiocomplex (Table 3) ; 3) the type of BTSE size and number of adjacent BTSE ratio, dominated by the number in the geobiocomplex.

The classification of geobiocomplexes according to horizontal structure is presented. The type level (I level) has the leading feature based on the all BTSE parts (%) ratio in geobiocomplex. A class (II level) has a leading feature based on the type of BTSE size and number of adjacent BTSE ratio, dominated by the area in the geobiocomplex. Differently from the classification of geobiocomplexes by the BTS physiognomy and vertical structure, this classification has only two typological levels – types and classes. Subclasses level was not discerned. The reason is that the last parameter – the type of BTSE size and number of adjacent BTSE ratio, dominated by the number in the geobiocomplex does not give the territorial differences. There are 24 classes, characterizing each geobiocomplex according the horizontal BTS features defined. Typological regionalization schemes of Lithuania, according to all features mentioned above were composed.

Table 6. Classification features of geobiocomplexes according to horizontal territorial structure of biota.

Horizontal structure types according to all BTSE parts (%) ratio in geobiocomplex				
1. [6]Matrix	**2.** [7]Poriferous background	**3.** [8] Large mosaic	**4.** [9]Fine mosaic	**5.** [10]Corridor

[6] BTSE occupies 100% of the geobiocomplex area;
[7] Patches occupies 0 - 40% of the (>60%) matrix in the geobiocomplex;
[8] No matrix element; the remaining BTSE occupies 50 - 60% of all geobiocomplex area;
[9] No matrix element; the remaining BTSE occupies 0 - 50% of all geobiocomplex area;
[10] The water flows discerned on the M 1:200 000.

According to horizontal structure (ratio of all BTSE area (%) in a territory; ratio of BTSE area and number of neighbours indices) the geobiocomplexes characterized by fine mosaic; small areas (<500 ha) with small number of neighbours (< 23 neighbours), dominated in highlands, prevail in Lithuania. The second type is patch matrix; large areas (>2000 ha) with big number of neighbours (>123 neighbours) in geobiocomplexes are dominant in West Žemaičiai Plateau, Central Lithuanian Plain and Southeastern Sandy Plain. The transitional type of horizontal structure going from uplands towards lowlands is large mosaic; average size BTSE with average neighbour number.

The significant edaphic characteristics of landscape biota territorial structure were chosen for the geobiocomplex description: 1) types of potential vegetation that is an expression of edaphic conditions, if there is no human impact on the Earth surface (Lithuanian vegetation map (Brundza, Pakalnis, Budriūnas, 1981) is used as a basis. It was improved according to results of factor analysis); 2) relief–lithology types (Lithuanian landscape morphologic map M 1: 400 000 (© Ministry of Environment; © JSC Urbanistika, 2001 is used as a basis).

These two features are used for the geobiocomplex classification according to edaphic conditions. The potential vegetation is a visual expression of edaphic conditions in the landscape. Thus it was used as a leading feature for the major classification category – types. Relief–lithology types were used as a leading feature for the formation of the lower taxonomical level – class level. There were 71 classes formed in this geobiocomplex classification. Typological regionalization schemes of Lithuania were formed according to these classification features.

According to edaphic conditions, reflecting the complex feature of potential vegetation and relief–lithology types, the most significant differences are observed between the following territories: Baltic coastal zone (sandy lowland dominated by mossy and shrubby pine forests *(All. Dicrano–Pinion)*); West Žemaičiai Plateau (south taiga shrubby spruce forests *(All. Piceion abietis)* and pine forests dominated by green mosses with elements of broad – leaved forests *(All. Dicrano–Pinion, All. Carpinion betuli, All. Alnion incanae)*; Central Lithuania (broad-leaved–spruce forests *(All. Piceion abietis, All. Carpinion betuli, All. Alnion incanae),* broad–leaved forests *(All. Carpinion betuli, Alnion incanae)*) and East–Southeastern Lithuania (sandy lowlands dominated by pine forests with green mosses *(All. Dicrano–Pinion)*).

Individual geobiomorphologic regionalization. The typological regionalization of the territory forms the basis for the separation of large regions, characterized by the unique geobiocomplex combinations (i.e. for the individual regionalization). Firstly, the individual regionalizations according to the parameters of BTS physiognomy, vertical and horizontal structures as well as edaphic conditions were composed. Afterwards, the integrated geobiomorphological regionalization of Lithuania was designed.

Regionalization according to the biota territorial structure physiognomy. Since the fragmentation feature reflects the most general impact on the natural cover of all our country *(percentage of forest cover in a geobiocomplex and the share of forest patches up to 2000 ha in a geobiocomplex),* it was chosen as a leading feature for the delineation of the largest regionalization units – **regions**.

The average distance to the nearest neighbour, reflecting the living organism dispersion characteristics in the regional level was chosen as the leading feature for the delineation of the boundaries of smaller regionalization units – **districts**. *The evaluation of the shape complexity* of each forest patch reflecting the local impact on the living organisms was chosen as a leading feature for the delineation of the smallest units – **subdistricts**.

There were 3 regions and 20 districts determined and 5 districts subdivided into subdistricts in the Lithuanian territory. Thus, there are 29 smallest territorial units in Lithuania.

Regionalization according to vertical biota territorial structure. The BTSE height reflects the most general vertical structure differences, important for biota; therefore the leading feature of the largest territorial units – regions – is the height type dominant by the area in the geobiocomplex. According to this parameter, four regions are obviously distinguished in Lithuania. The edge contrast index specifies the impact between the adjacent BTSE. The woody BTSE have the highest contrast level and biggest influence to adjacent BTSE. They reflect the territorial differences of a vertical structure on a regional level. Therefore, the edge contrast index prevalent by the area in the geobiocomplex indicates the most heterogeneous territories and was chosen to delineate *regional* level of territorial units – districts. Subdistricts were defined according to the edge contrast index dominated by the number in the geobiocomplex. This feature delineates the homogenous territories especially in Central Lithuania.

Consequently, 3 regions, 13 districts were delineated and 5 districts were subdivided into subdistricts according to vertical biota territorial structure on the Lithuanian territory. Therefore 29 smallest territorial units were formed.

Regionalization according to the horizontal biota territorial structure. The leading feature of the largest regionalization units – regions delineation is the dominated type of all BTSE parts (%) ratio in geobiocomplex. It accurately reflects the main orographic units of Lithuania – highlands and lowlands. Districts were delineated according to the type of BTSE size and number of adjacent BTSE ratio, dominated by the area in the geobiocomplex. This feature discerns the transitional areas between highlands and lowlands and shows the regional differences of biota territorial structure. The smallest regionalization units – subdistricts were not discerned since the prevailing territorial structure according the type of BTSE size and number of adjacent BTSE ratio, dominated by the number in the geobiocomplex, is quite homogeneous. There were 4 regions and 19 districts determined in the Lithuanian territory.

Regionalization according to the geobiocomplex edaphic conditions. There were two features reflecting edaphic conditions used for the regionalization of Lithuanian territory in this work. Since the potential vegetation is a visual expression of abiotic conditions in the landscape, it was chosen as the leading feature to delineate the largest regionalization units – regions. Relief–lithology types, discerning the differences of edaphic conditions, were chosen as the leading feature for the delineation of the smaller territorial units – districts. 4 regions and 32 districts were delineated.

Integrated geobiomorphological regionalization. The integrated geobiomorphological regionalization was composed, according to the edaphic conditions and structural biota territorial structure features. Each taxonomical level has a leading feature.

If Lithuanian surface was not affected by the human activity, the features of landscape biota territorial structure would depend only on edaphic differences. Therefore edaphic conditions, described by the complex of potential vegetation and relief–lithology became the leading feature of the largest individual regionalization units – regions.

The feature complex describing biota territorial structure physiognomy characterizes the contemporary earth surface transformed by the human activity. The parts of regions that were affected by the different influence of human being and obtained the different landscape visual outlook are considered to be the districts.

However, a district is quite large territorial unit. A different mosaic of patches (various structural combinations of BTSE) is being formed under the influence of human activity inside the one district. These differences of the Earth surface differentiate the biota complexes and create different living conditions. Therefore, the parts of districts that obtained the different features of horizontal structure are considered to be the lower level regionalization units – I level subdistricts.

The horizontal biota territorial structure differences do not describe the interconnections of living organism habitats (i.e. how much the influence of one BTSE penetrates into the adjacent BTSE). This feature determines the interaction of living organisms in the local level as well as the character of habitat transitional zones. These parts of subdistricts, where the different vertical types BTSE are discernable are the lowest regional stage units – II level subdistricts.

Thus, 4 regions, 24 districts, 21 I level subdistricts and 17 II level subdistricts were delineated in the territory of Lithuania (Fig. 2). There are 48 smallest territorial units in total.

In summary, it is possible to outline the general features of Lithuanian biota territorial structure. Anthropogenic and anthropogenized biota territorial structure type prevail in Lithuania. The highest degree of anthropogenization is typical of the districts of Pajūris Lowlands, Kuršas Uplands, northern valleys of Venta River, Žiemgala, Central Lithuania,

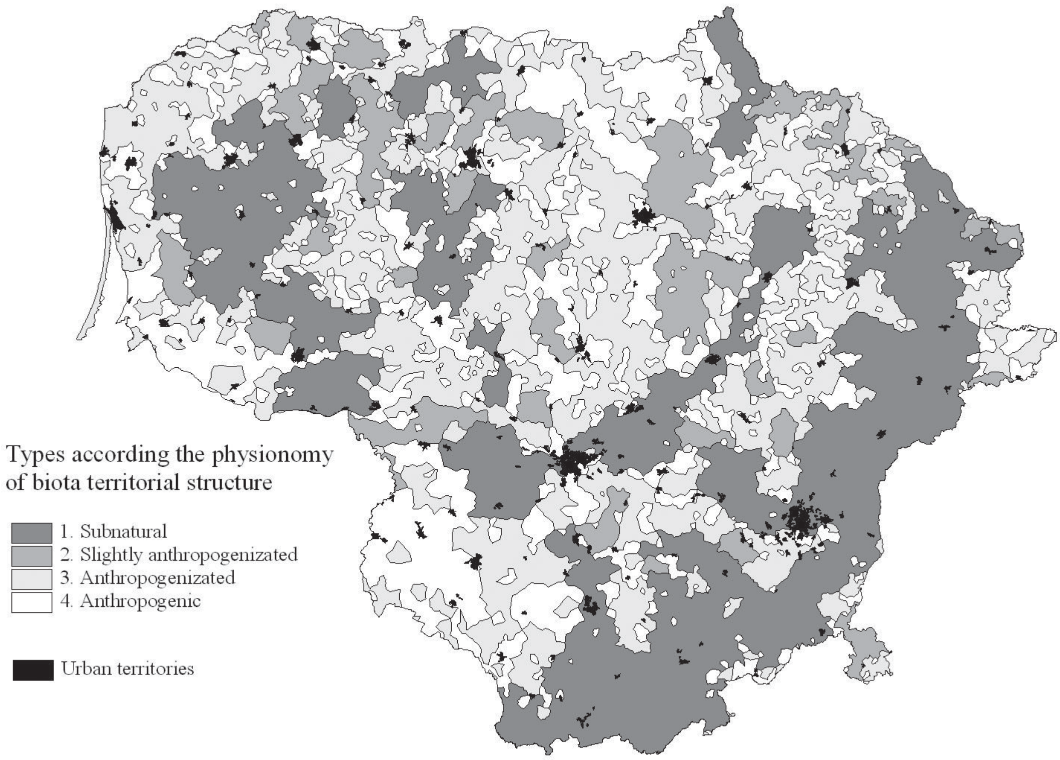


Fig. 2. Complex geobiomorphological regionalization of Lithuania.

Žemaičiai Upland, Eastern Žemaičiai–Karšuva and Sūduva lowlands as well as Sūduva Highlands. The geobiocomplexes are characterized by weak or very weak connections and by low complexity or incomplex forest patch shapes. Nemunas delta and its deltaic valley stand out from all Lithuanian vertical structure, by dominance of low height and homogeneous BTSE. Patchy matrix horizontal structure prevails in all subdistricts of the above-mentioned districts with exception of Pajūris lowland and Žemaičiai Upland subdistricts, where the fine mosaic territories dominate. The first type indicates the territories of intensive agriculture.

The districts situated mostly in Lithuanian highlands are less affected by the human activity, but are still characterized by anthropogenic and weakly anthopogenized biota territorial structure type (Venta – East Žemaičiai Plateau, Nemunas valley – Dzūkai Uplands, Aukštaičiai Upland, Medininkai – Riešė Uplands; Švenčioniai, Ašmena and Dysna districts). Average height and average homogenous biota territorial structure prevail. The dominant horizontal structure is characterized as fine mosaic horizontal structure - small BTSE (up to 500 ha) are dominating in the geobiocomplexes.

Only 6 districts (out of 24) can be characterized by the subnatural landscape. These are Curonian Spit, Baltic coastal area, West Žemaičiai Plateau, Nemunas valley, Eastern part of Central Lithuania, Laky complex–Žeimena Lowland, Vokė–Merkys–Dainava Lowland districts. They are characterized by high BTSE and heterogeneous vertical biota territorial structure.

A woody patchy matrix territorial structure is forming in the subdistricts of these lowlands (Curronian Spit, Baltic coastal area, Nemunas valley, Žeimena Plain, Vokė–Merkys and Dainava lowlands subdistricts). The same horizontal structure is identical to the territories of intensive agriculture. However, the matrix is comprised not by the cultivated field habitats, but by the subnatural large forested areas in the above-mentioned subdistricts.

To conclude, nowadays, the abiotic environment conditions are not the single determinant, influencing the formation of the landscape biota territorial structure. The differences of Lithuanian zonal vegetation cover – forests essentially can be analysed in the terms of potential vegetation in our contemporary anthropogenizated landscape. A human being creates the vegetation cover combinations, consisting of the different size and configuration patches. They constitute heterogeneous landscape mosaic. The consistent patterns of it physiognomy, vertical and horizontal arrangement influence the habitat conditions of living organisms. Therefore, the human impact is the most important precondition when analysing the consistent patterns of landscape biota territorial distribution and territorial morphology peculiarities.

Consequently, the landscape biomorphostructure exists together with the well - studied lito-, pedo-, hidro-, techno- and other structures of Lithuanian landscape. This structure obtains edaphic features from the abiotic landscape components (surface rocks, soil, relief) and structural features from anthropogenic component. Thus, an individual biota territorial structure is being formed in the landscape. Delineation of its territorial units – geobiocomplexes and the regionalization of Lithuanian territory by its characteristic features contributes to the cognitive system of natural and anthropogenic landscape components and constitutes the integrated geographical territorial structure model of landscape biotic component.

Conclusions

1. The research of the dynamic landscape component – biota (in broad sense) was put apart in the Lithuanian landscape geography science, as a focal research point of it was always considered to be the stable lithological basis. Biota plays a passive (visual–indicational) role in the majority fundamental works of landscape geography and is considered as one of the constituents of landscape morphological units. However, the increasing human activity and the disappearance of landscape diversity form a strong motivation to research the landscape changes from the biota territorial structure point of view.

2. The notion of landscape biota territorial structure formed in this work reflects the morphological peculiarities of biotic landscape component in the ecosystem level. Ecosystems themselves become the cartographical objects – biota territorial structure elements (BTSE), continuously covering the Earth surface. This fact enables the theoretical aspects of BTSE morphology (BTSE physiognomy, vertical and horizontal situation) transform to the fundamental features of landscape biota territorial structure.

3. The methodology, specifying the natural–geographical peculiarities of biotic landscape component – vegetation was created. It could be adapted to determine the correlation features of spatial distribution of the others correlated landscape components.

4. The notion of landscape biota territorial structure units – geobiocomplexes was formed and the methodology of their discernment was proposed. It is based on the typical BTSE combinations, appearing in the territory of homogeneous edaphic conditions. There are 3367 territorial units determined in Lithuania's territory. Such a small division of our country into the territorial units, characterized by the different biotic structure is a sufficient basis for the detailed analysis of landscape biota territorial structure features.

5. There are 8 typological, 4 individual and the one integrated individual geobiomorphological regionalization of Lithuania composed in this work. It reflects the regions of different biota edaphic conditions and structural feature combinations, contributes to the cognitive framework of natural and anthropogenic landscape components and constitutes the integrated geographical territorial structure model of landscape biotic component.

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Kraštovaizdžio biotos teritorinės struktūros morfologija (Lietuvos teritorijos pavyzdžiu)

Santrauka

Kraštovaizdžio geografijos moksle didžiausią dėmesį skiriant stabilaus litogeninio pamato tyrimams, ilgainiui į šalį buvo atidėtas dinamiškas, nepastovus kraštovaizdžio komponentas – biota (plačiąja prasme), daugelyje fundamentinių darbų suprantama kaip atliekanti pasyvią (vizualinę-indikacinę) funkciją bei esanti morfologinių kraštovaizdžio vienetų dedamoji dalis. Šiuo metu dėl sparčios antropogeninės invazijos, nykstant kraštovaizdžio įvairovei atsiranda būtinybė į kraštovaizdyje vykstančius pokyčius pažvelgti pro biotos teritorinės struktūros prizmę.

Kraštovaizdžio biotos teritorinė struktūra nebepriklauso vien nuo abiotinių aplinkos sąlygų. Dabartniame kraštovaizdyje natūralią zoninę mūsų krašto augalinę dangą – miškus – iš esmės galima analizuoti tik „potencialios augalijos" sąvokos rėmuose. Žmogus, antropogenizuodamas Žemės paviršių, sukuria savitus augalinės dangos derinius. Šie formuoja įvairialypę vizualinę kraštovaizdžio mozaiką, kurios pobūdžio, vertikaliojo ir horizontaliojo išsidėstymo ypatybės veikia gyvųjų organizmų gyvenamąsias sąlygas. Todėl kraštovaizdžio biotos teritorinio pasiskirstymo dėsningumų neįmanoma nagrinėti be žmogaus poveikio aplinkai, atspindinčio biotos teritorinės morfologijos subtilybes.

Darbe suformuluota kraštovaizdžio biotos teritorinės struktūros samprata nusako biotinio kraštovaizdžio komponento morfologines ypatybes ekosistemų lygmeniu. Pačios ekosistemos virsta realiai kartografuojamais, tolygiai Žemės paviršių dengiančiais biotos teritorinės struktūros elementais (BTSE). Tai įgalina teoriškai klasifikacijoje atsispindinčius BTSE morfologinius aspektus (pobūdį, vertikaliąją bei horizontaliąją padėtį) perkelti į objektyvią realybę ir transformuoti į kertinius kraštovaizdžio biotos teritorinės struktūros požymius.

Todėl, be išsamiai išnagrinėtų Lietuvos kraštovaizdžio, litologinio, pedologinio, hidrologinio, technologinio ir kitokio pobūdžio struktūrų, egzistuoja itin svarbi – tarpinė kraštovaizdžio morfostruktūra, kuri iš abiotinių kraštovaizdžio komponentų (paviršinių uolienų, dirvožemio, reljefo ir pažemio oro) įgauna edafinių bruožų, o iš antropogeninio komponento – struktūrinių ypatybių. Taigi kraštovaizdyje formuojasi savita biotos teritorinė struktūra. Jos teritorinių vienetų – geobiokompleksų nustatymas bei Lietuvos teritorijos rajonavimas pagal jai būdingus požymius įtraukiamas į bendrą kraštovaizdžio gamtinių ir antropogeninių komponentų bei ryšių pažinimo sistemą ir formuoja integruotą geografinį kraštovaizdžio biotinio komponento teritorinės struktūros modelį.