ENVIRONMENTAL PROBLEMS

Vol. 2, No. 4, 2017

LANDSCAPE METRICS FOR CHANGES DETECTION IN LAND COVER OF THE WEST POLESIE TRANSBOUNDARY BIOSPHERE RESERVE

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Received: 17.11.2017

Abstract. The actuality of the present paper is substantiated by the need in preservation the landscape and biological diversity of nature-protected territories to achieve the ecologically optimal structure of land use as one of the main targets of their sustainable development. The paper describes methodological approaches to analysis of the nature-protected territory landscape diversity, presents the landscape metrics, calculated using the FRAGSTATS software as well as images of their spatial distribution.

Key words: landscape diversity, space images, classification, landscape metrics, FRAGSTATS, West Polesie Transboundary Biosphere Reserve.

1. Introduction

During last decades one of the main environmental practices both in Ukraine and in the most developed countries is to preserve the landscape and biological diversity as well as to prevent the processes of their reduction. Priority directions in the above-mentioned activities were defined by the Pan-European Biological and Landscape Diversity Strategy [1] and European Landscape Convention [2].

The point is that the landscape diversity studying becomes one of the foreground questions in natural sciences. A methodological requirement for studying the landscape diversity and its changes is the application of both the ground-based and the cartographic methods of analysis as well as space images, obtained during the Remote Sensing of the Earth. On the one hand, the application of such an approach is connected with planning the rational land use under the strong land resource deficit for conserving the biological diversity and supporting the high productivity of protected ecosystems. On the other hand, the intensification of anthropogenic transformations of West Polesie natural landscapes requires effective facilities for the land management at simultaneous preservation the habitats, necessary for rehabilitation the biological diversity and other natural resources [3].

A critical deficit of land resources on nature-protected territories depends on the environmental law, intensification of state and private interests in using lands for building, recreational economy as well as the increasing demand for forest and agricultural products. At that, specific natural conditions of West Polesie, restrict the possibilities of spatial development of local infrastructure, which are defined for providing the preservation of valuable ecosystems. A major part of West Polesie territory includes different bogs. Large areas are occupied by aquatic ecosystems that, on the one hand, attract land users and, on the other, restrict the building and other economic activities. A protected regime on most territories must be a regulated process. In addition, this regime, itself, doesn’t provide a long-term preservation of natural resources, especially such as biological diversity and valuable landscape formations. Actually, the absence of programs for providing the activities, which are directed to support the natural values, leads to their gradual disappearance or transformation into disturbed structures with losses of landscape components and biota species. Under such conditions, the exigency to improve the land use planning appears. The basis of the above-mentioned planning must be the reasons analysis of natural ecosystem disturbance.

Landscape structure is a principle of landscape organization. It is defined not only through its usage, but through its structure, size, form, organization and distribution of separate landscape elements. The landscape elements (“patches”) such as “land cover” and “land use” are often used for delimitation. In this context, “land cover” belongs to a physical characteristic of earth surface, while “land use” describes economic and social functions of the territory [4].

Spatial distribution and landscape element types play a significant role in ecological functionality and biological diversity of any natural environment. It’s vital to note that one of the major methods of quantified estimation of the landscape structure (land cover) is the landscape metrics (LM) calculation. They can be used for description both the separate landscape elements and the landscape diversity in general. Results of LM usage allow us to receive quantified landscape characteristics as well as information for monitoring purposes. Moreover, they can be used as input parameters for landscape ecological modeling.

Sharp progress in fields of Remote Sensing of the Earth (RSE) and geoinformation technologies gives ample opportunities for using the satellite data and results of their processing for estimation the diversity of nature-anthropogenic landscapes. Along with landscape features, investigated using satellite images, one can receive not only a qualitative but quantitative estimation.

Geoinformation systems (GIS) are necessary for the landscape structure analysis using the landscape metrics. GIS allow one to estimate a large volume of spatial information (e.g., information about land use, soil types, forests etc.) and to calculate the landscape metrics, combining these data with other. Landscape GIS analysis based on LM was performed by [5]. The landscape metrics were used for nature preservation and landscape study by [6] and [7]. However, the application of different landscape metrics for studying the landscape structure changes became widespread, especially on nature-protected territories [8–11].

Currently, a row of specialized software for LM calculation is available, for example FRAGSTATS [12], Patch Analyst [13] and V-LATE [14]. Information about land management, collected from ground-based efforts or satellite images, is used as the main data [15].

A complexity and success of the performed analysis depend on the landscape type and objective of the study. One of the main problems during the analysis of such structures is a clear definition and delimitation of the landscape elements what can be complicated for some landscapes. Therefore, some authors propose to consider the landscape in the form of gradients [16, 17].

Relief of the territory, usually, is not considered during the GIS-analysis and landscape metrics calculations. For lowlands, such as the West Polesie Transboundary Biosphere Reserve (WP TBR) territory, neglect by relief is permissible at LM calculations. But, in the case of relief complexity increase, calculation of the landscape metrics can lead to mixed results [18–21].

Furthermore, thematic and geometric resolution affects the results of LM application [22–24]. There is one more important point that a scale [25] and spatial resolution of data should match [26]. For example, the research of [27] shows that spatial resolution of 30 m was insufficient for the analysis of bird habitats. Therefore, application of certain spatial resolution data depends on the purpose of research.

It is understandable that the landscape level, as a part of the preservation problem, demands the higher attention. One can observe the increasing number of research works about the relationship between the landscape structure and the biological diversity [28–31]. They explain the appearance and distribution of species from local to global level [32] taking into account a spatial heterogeneity of landscape structure.

Numerous researches prove that the protection on the landscape level and the related control of the landscape matrix are more effective than the preservation of separate species and a habitat [33]. It is more difficult to develop a common concept of preservation on species level than on species diversity level [34, 35]. Against this backdrop, the landscape level looks more important for management of biodiversity. Besides, the conservation strategies on this level should have more success [36].

The nature-protected territory of the WP TBR (Belarusian-Polish-Ukrainian Borderland) comprises numerous unique natural complexes, including rare species of flora and fauna. Any changes of landscape diversity are essential for the preservation of these complexes and species.

In the current conditions there are a significant number of approaches to estimate the landscape diversity. But for large territories, such as TBR, the approach to estimate the landscape diversity based on LM calculations using satellite data, is still relevant [37–42].

The above approach for estimation the landscape diversity is used by different researchers within separate areas of the West Polesie Transboundary Biosphere Reserve. But the fact of gaining the WP TBR a legal status requires a formulation of common approaches to management of this territory and performance of its functions. Since the landscape structure is a key element for understanding the species diversity of any territory, therefore the estimation of this territory on the landscape level is a topical challenge today.

Thus, the goal of the current work is to identify changes in landscape diversity on the WP TBR territory because of disappearance or disturbance of the natural landscapes, due to both natural and anthropogenic factors.

2. Materials and methods

2.1. Study area

UNESCO West Polesie Trilateral Transboundary Biosphere Reserve was established in 2012 by a consolidation of three separate Biosphere reserves, namely: "POLESIE ZACHODNIE" (Poland), "SHATSKYI" (Ukraine) and "PRIBUZHSKOYE POLESIE" (Belarus) (Fig. 1). The general area of the Biosphere Reserve is 264 000 ha. The Ukrainian part is 75 000 ha, Poland – 140 000 ha and Belarus – 49 000 ha. Consolidation of efforts is the aim of the Reserve establishment for protection flora and fauna, preservation the rare wetlands and water resources of Polesie Region [43].

The relief of the WP TBR is mostly flat with absolute altitude 150–170 meters above sea level. On the scale of whole Europe, this territory includes unique areas with natural forest complexes and wetlands [31, 44].

The West Polesie Region plays an important role in climate formation for the most part of European continent due to its geographical spread on the European watershed along with the existence of many rivers, lakes, wetlands etc.

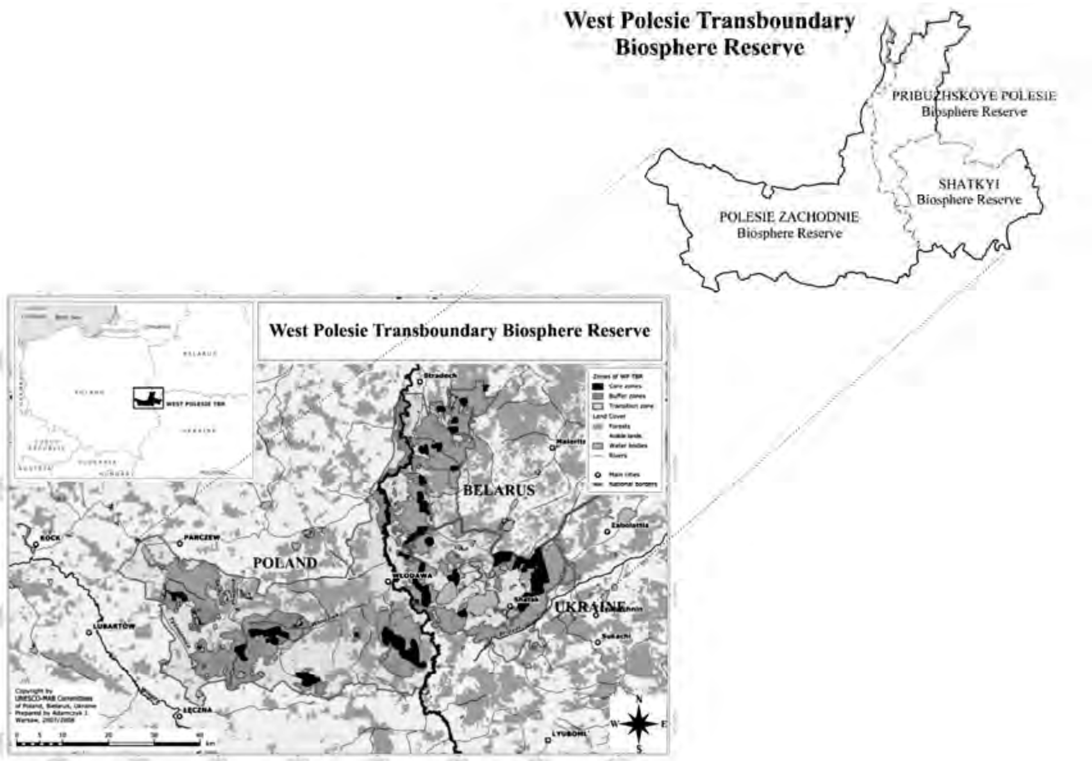

Fig. 1. UNESCO West Polesie Transboundary Biosphere Reserve [45]

However, a sustainable development of the TBR nature-protected territories requires a purposeful and science-based interference of human into management processes, because of influence the regional climate and anthropogenic loads [44, 46–48].

2.2. Data acquisition and processing

Two satellite images of MODIS Land Cover Type (MCD12Q1) for the period 2001–2013 were used. This product includes five classified images of the land cover with the 500 m spatial resolution. Among them, we use a classification IGBP (International Geosphere Biosphere Programme) scheme that includes 17 classes of the land cover [49] (Fig. 2).

Satellite images processing was performed in ArcGIS 9.2. Calculation of LM in FRAGSTATS Software [50] was carried out on two levels:

- Class level. Nine metrics were calculated for 15 classes (Total Area, Number of Patches, Landscape Shape Index, Aggregation Index, Splitting Index etc.);
- Landscape level. Six metrics were calculated for all classification mosaic (Shannon's and Simpson's Evenness, Patch Richness Density, Patch Richness).

The region of interest was marked on Land Cover Type 1_ (IGBP) layer from the MCD12Q1 dataset (2001-2013) using ArcGIS software in the GRID and TIFF formats.

Thematic maps of landscape metrics distribution were created in FRAGSTATS. Quantitative values of the average width of ranges were calculated for 2001 and 2013 using different moving window diameters.

Table 1 shows the average width of ranges, which were calculated using 12 classified satellite images (six per each year) for the following metrics: Patch Richness (PR), Patch Richness Density (PRD), Shannon's

Diversity Index (SHDI), Shannon's Evenness Index (SHEI), Simpson's Diversity Index (SIDI) and Simpson's Evenness Index (SIEI).

The moving windows diameter (hereinafter a window width) is based on coverage the maximum data range. Thus, using the window width of 1 500 m, it is difficult to identify the main trends of spatial distribution of the values (Fig. 3, *a*). The increase of diameter up to 10 000 m leads to the decrease of image data resolution (Fig. 3, *b*). Comparing the value ranges for six metrics calculated using window widths 1 500, 2 000, 3 000, 4 500, 7 000 and 10 000 m it was found that metrics with the window width of 4 500 m have the optimal ranges. Maximum approximation of the Number of Patches (12), which conform to the window width of 4 500 m (Table 1), to the number of classes of the output classification (Fig. 2) proves the stated above result.

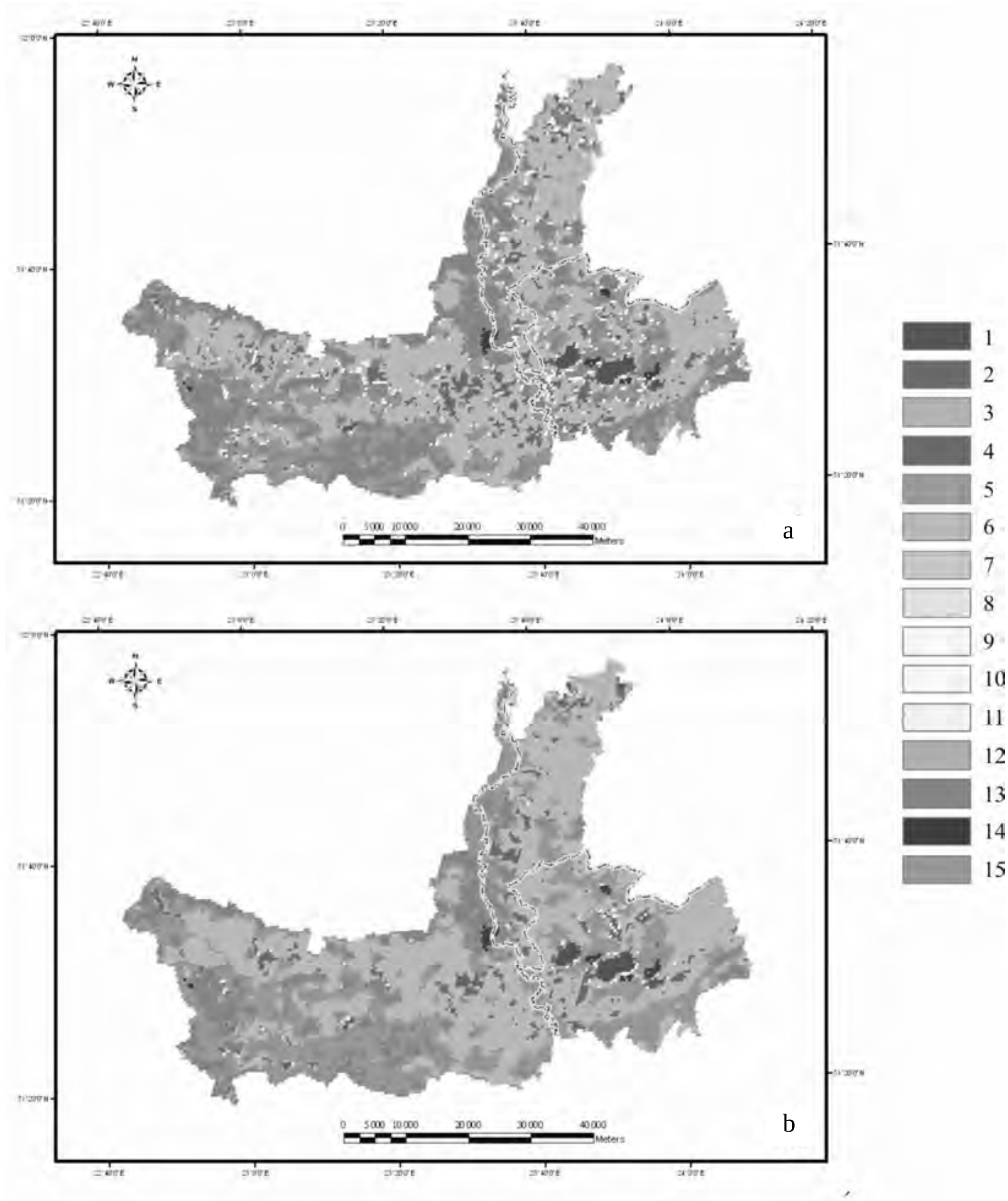

Fig. 2. Output classifications of the land cover (MCD12Q product) on WP TBR territory:
a – 2001, b – 2013. IGBP classes: 1 – water bodies; 2 – evergreen needleleaf forest;
3 – evergreen broadleaf forest; 4 – deciduous needleleaf forest;
5 – deciduous broadleaf forest; 6 – mixed forest; 7 – closed shrublands; 8 – open shrublands;
9 – woody savannas 30–60 %; 10 – savannas 10–30 %; 11 – grasslands; 12 – permanent wetlands;
13 – croplands; 14 – urban and built-up lands;
15 – cropland/natural vegetation mosaics

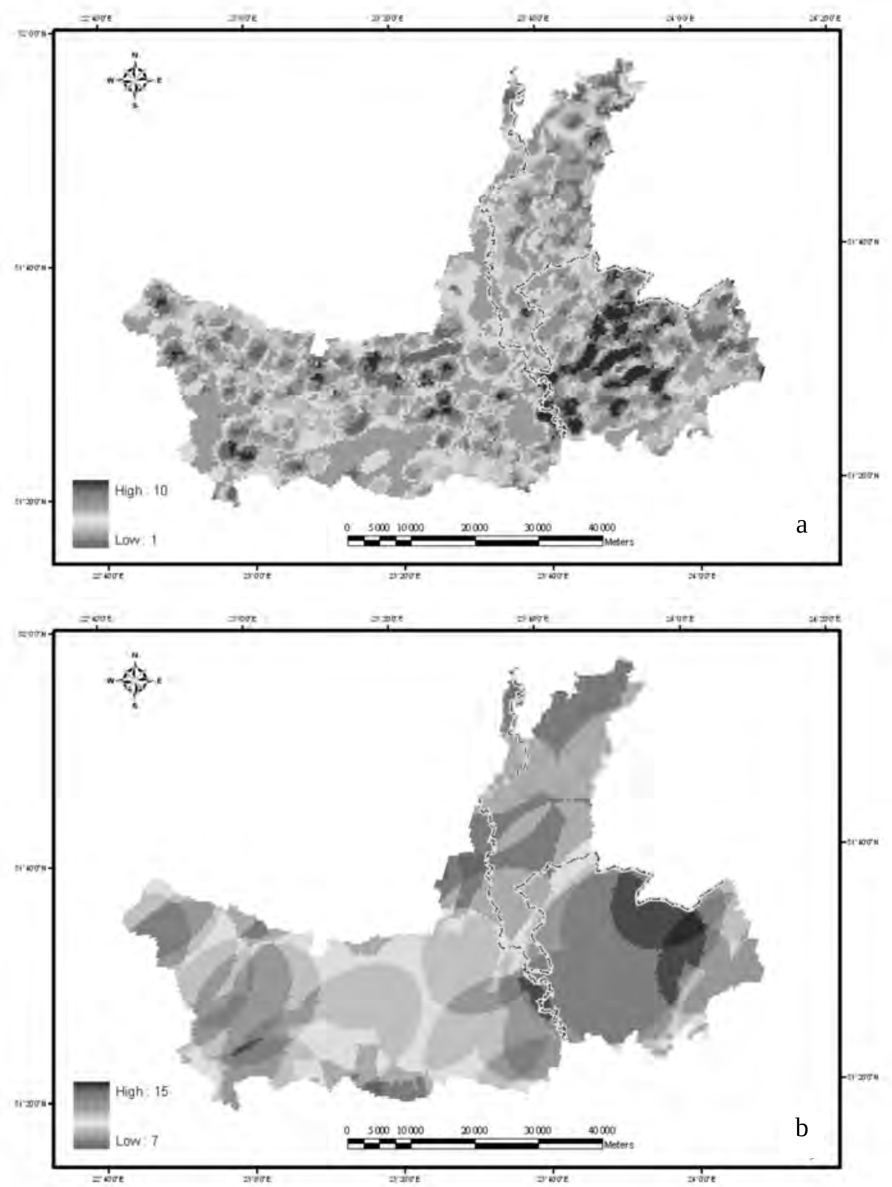

Fig. 3. Spatial distribution of the Number of Patches in 2001 for the window width equals:
a – 1 500 m; b – 10 000 m

Table 1

Average width of ranges in 2001 and 2013 for landscape metrics at different window width

Metric/ window width	750 m	1 500 m	2 000 m	3 000 m	4 500 m	7 000 m	10 000 m
Patch Richness (PR)	4	10	11	11	12	11	9
Patch Richness Density (PRD)	3.73	1.44	0.95	0.41	0.2	0.07	0.03
Shannon's Diversity Index (SHDI)	1.61	2.02	2.04	2.01	1.84	1.24	1.08
Shannon's Evenness Index (SHEI)	1	1	1	0.92	0.86	0.45	0.35
Simpson's Diversity Index (SIDI)	0.8	0.85	0.86	0.84	0.78	0.45	0.32
Simpson's Evenness Index (SIEI)	1	1	1	0.96	0.89	0.47	0.3

Except indices of the landscape diversity, a set of class level metrics for subsequent analysis was defined [51]: Total area (TA/CA), Number of Patches (NP), Landscape Shape Index (LSI), Percentage of Like Adjacencies (PLADJ), Interspersion and Juxtaposition Index (IJI), Patch Cohesion Index (COHESION), Effective Mesh Size (MESH), Splitting Index (SPLIT) and Aggregation Index (AI).

3. Results and discussion

As the result of analysis, the following changes of the WP TBR land cover during 2001–2013 should be noted, namely: increase of forest area by 1.5 %, cropland/natural vegetation mosaics – by 11.2 %, wetlands increase more than 6 times (2001 – 343 ha; 2013 – 2 190 ha). The main reason for such changes is the sharp decrease of agricultural activity during last decades what is proved by the croplands decline in two times.

Table 2 shows average values of landscape diversity annual indices for the WP TBR. For more detailed analysis, maps of spatial distribution of the above-mentioned metrics are used.

The PR metric is calculated without taking into account a spatial distribution of class fragments within the landscape. Its value range in 2011 fluctuates from 2 to 13 classes with their uneven distribution within the TBR territory (Fig. 4, *a*).

High diversity of the landscape elements is inherent to the Ukrainian part of TBR territory, namely to the Shatskyi Biosphere Reserve. The highest values of this index are distinctive for coastal areas of Svitiaz Lake (Fig. 1). During the 12-year period areas with the highest values of the above-mentioned index (13) disappeared. At the same time, areas with the lower values of PR increased. The fact is that in 2001 the dominant values vary from 6 to 9 and in 2013 from 3 to 6 (Fig. 4, *b*). Such homogeneity of the territory led to impoverishment of the class diversity by the decrease of croplands, which, in turn, were transformed into natural vegetation mosaics (e.g., meadows). Also, woodlands are overgrown with their further transformation into mixed forest.

Table 2

Landscape metrics values in 2011-2013

Year/ metric	PR	PRD	SHDI	SHEI	SIDI	SIEI
2001	15	0.0051	1.5121	0.7241	0.5584	0.7758
2013	13	0.0044	1.3054	0.6579	0.5089	0.7128

Patch Richness Density (PRD) Index normalizes the diversity values per unit of area and is derived metrics of PR [12].

Shannon's Diversity Index (SHDI) measures the diversity taking into account the prevalence and evenness, in other words, the number of landscape classes and their even distribution within the investigated area. In case the index is zero, we have only one class. The increasing number of classes or their distribution leads to the index value increase. The normal values of this index vary from 1.5 to 3.5 rarely exceeding 4.5 and are calculated by [12]:

$$SHDI = -\sum_{i=1}^{m}(P_i \ln P_i)\,, \qquad (1)$$

where m – number of landscape classes; P_i – part of the landscape, occupied by *i*th class type.

As an information indicator of biological diversity, Shannon's Diversity Index is widely used since the middle of the last century [52].

Results received at SHDI calculations prove the tendencies of PRD distribution. Areas with index values more than 1.2 decreased in three times during investigation period, therefore the areas with the high landscape diversity (SHDI < 1.2) increased (Fig. 5).

Shannon's Evenness Index (SHEI) shows the even distribution of classes. The SHEI range varies from 0 to 1. At the same time, SHEI equals zero, when within the landscape there is only one class (no diversity) and equals one, when each class was distributed evenly, having the largest diversity. Fluctuations of this index correlate with the diversity index changes.

Simpson's Diversity Index (SIDI) [53] is one more widely used measure of the landscape structure specific difference. Its essence lies in using the sum across all patch types to the proportional abundance of each patch type and is calculated according to [12]:

$$SIDI = 1 - \sum_{i=1}^{m} P_i^2 . \qquad (2)$$

Landscape diversity, or rather Shannon's Index, has the uneven distribution on the Biosphere Reserve territory. As it was stated above, the WP TBR includes the Reserves of three countries, which differ according to their nature components, development, and use of the nature-protected territory. For example, the Belarusian part of TBR is mostly presented by forests (more than 60 % of the territory) and thus it is characterized by the low level of landscape diversity. The highest values of Shannon's Index can be observed within the Bug river valley presented by the diversity of natural floodplain meadows and croplands.

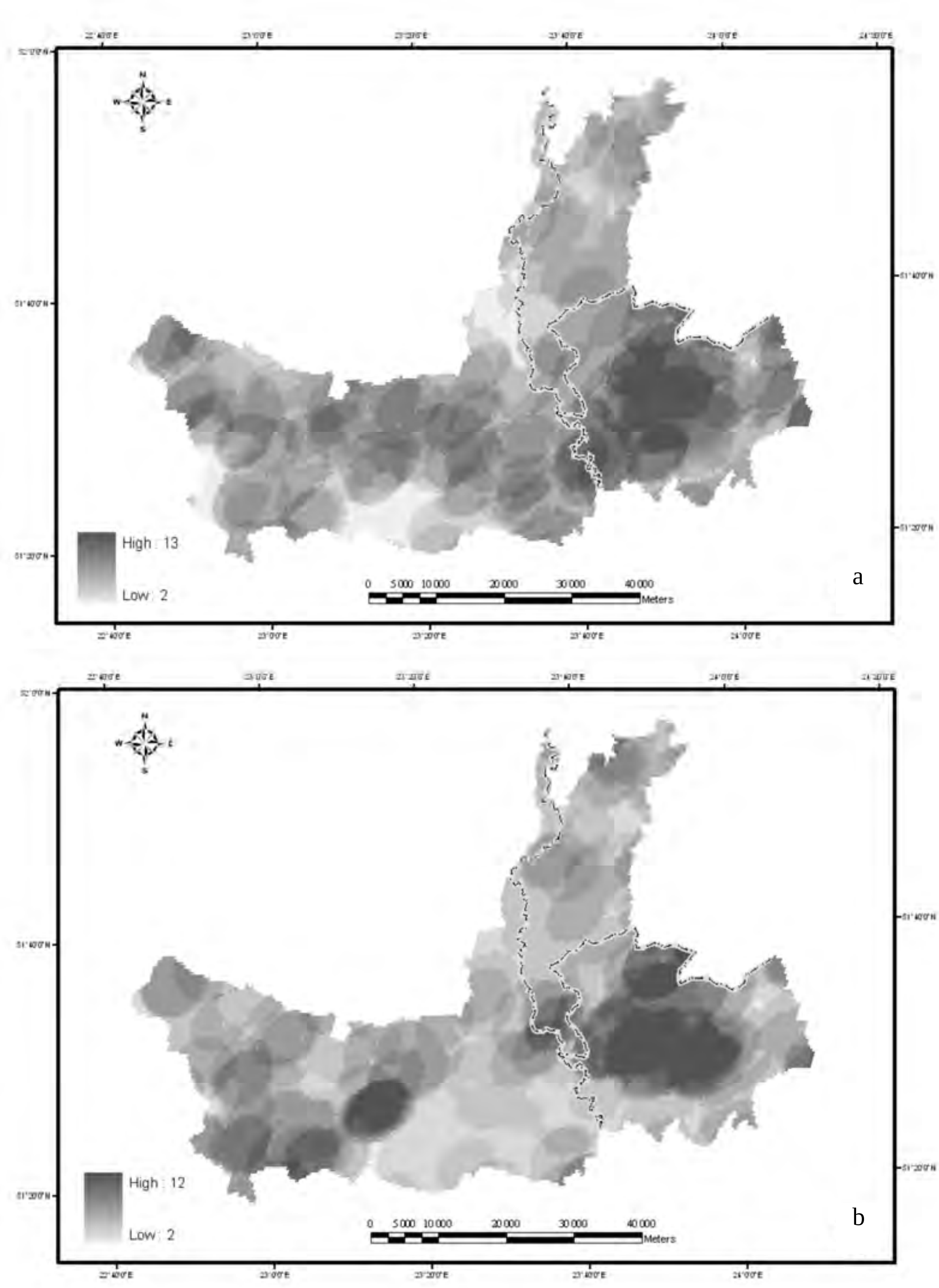

Fig. 4. Spatial distribution of the PR: a – 2001; b – 2013

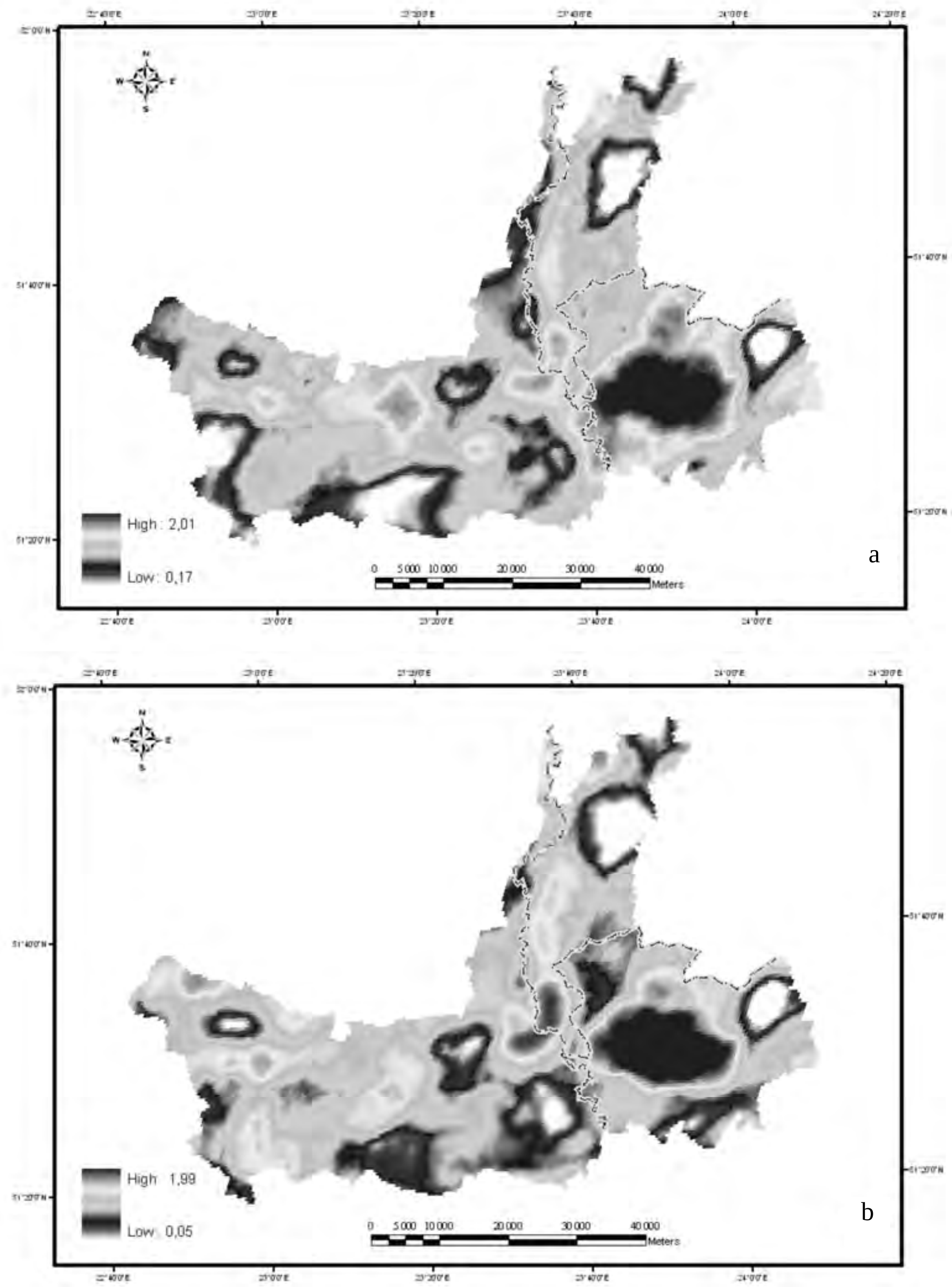

Fig. 5. Spatial distribution of SHDI: a – 2001, b – 2013

For the Polish part of the TBR, the most diverse are, predominantly, natural areas, which are mosaics of water, bog, forest and meadow ecosystems. For large forest massifs and agricultural lands (meadows and croplands) one can see the less diversity.

The same tendency can be observed for the Ukrainian part of the TBR. As it was mentioned above, here the landscape diversity is peculiar for coastal areas of large lakes. These areas consist of both natural and anthropogenic landscapes. The eastern part of the Shatskyi Biosphere reserve is less varied because of the large forest massifs. The same situation one can see in the Bug river valley presented by croplands and lands with natural vegetation mosaics.

For landscape diversity analysis, nine IGBP classes characterizing the features of landscape structures according to the WP TBR land cover were used.

Distribution between the classes, which dominate in the landscape structure, is distinctive for the TBR territory. These classes include mixed forests, natural vegetation mosaics and croplands (Table 3). The other class group includes croplands/natural vegetation mosaics, shrublands and grasslands. Besides, any component does not occupy more than 60 % of the area [54]. Analyzing the distribution and its features during 12 years, the croplands decrease by 50 percent was fixed. At that, if in 2001 this type of land cover occupied 22.5 %, then in 2013 – 11.1 %. On the one hand it confirms a positive tendency of plowed lands decrease that supports the ecologically favorable ratio of areas of different land cover types, and thus has a positive influence on landscape stability. On the other hand such changes have some negative economic nature. They suggest a large-scale agricultural production decline that, in turn, negatively influenced the quality and diversity of landscapes.

Table 3

Class areas of WP TBR land cover and their changes during 2001–2013

	Class area				Relative growth, %
	2001, ha	2001, %	2013, ha	2013, %	
Water bodies	2983.756	1.02	3069.619	1.05	2.88
Evergreen needleleaf forest	17108.3	5.84	12815.120	4.38	-25.09
Deciduous needleleaf forest	300.5221	0.10	1008.896	0.34	235.71
Evergreen broadleaf	2790.563	0.95	1631.406	0.56	-41.54
Mixed forest	114477.5	39.11	126927.7	43.36	10.88
Open shrublands	42.9317	0.01	42.9317	0.01	0.00
Woody savannas 30-60 %	7598.917	2.60	987.4299	0.34	-87.01
Savannas 10-30 %	1674.338	0.57	21.4659	0.01	-98.72
Grassland	1245.02	0.43	579.5784	0.20	-53.45
Permanent wetlands	343.4539	0.12	2189.519	0.75	537.50
Croplands	65728.49	22.46	32606.65	11.14	-50.39
Urban and build-up lands	1524.077	0.52	1524.077	0.52	0.00
Cropland/natural vegetation mosaic	76418.49	26.11	109304.2	37.34	43.03
Deciduous broadleaf forest	450.7832	0.15	–	–	–
Closed shrublands	21.4659	0.01	–	–	–

Table 4 shows changes in the landscape metrics of the class level for the period of 2001–2013. According to calculations one can say that the overall percentage of all forest massifs (evergreen needleleaf, deciduous needleleaf, evergreen broadleaf, deciduous broadleaf and mixed forests) have increased by 2.6 %. In particular, the area of mixed forest increased by 4.2 % (for 12450.09 ha during 2001–2013). At the same time, the territories under woody savannas 30–60 % and savannas 10-30 % greatly decreased what show their transformation into mixed forests class. Grasslands decreased in two times (2001 – 1.2 thousand hectares, 2013 – 0.6 thousand hectares). Areas of natural vegetation mosaics increased by 11.2 % owing to declination and overgrowth the agricultural lands.

Despite the insignificant share of permanent wetlands (Table 3), their area in 2013 considerably increased by 1846.07 ha (Table 4). Such changes are an effect of the decrease in melioration works, the results of which, during last century led to negative ecological effects.

Lands of natural vegetation mosaics are the most fragmented class: the number of patches in 2001 is 227, while in 2013 – 96 (Table 4). This class is characterized by maximum shape unevenness (LSI decreasing by 6.37 during 2011–2013) and by higher values of cohesion (increasing on 5.27 % during 2011–2013). Splitting of this land cover type is insignificant and decreases over the years (SPLIT decreasing by 204.58 ha). Aggregation (AI Index) of this class type is sufficiently high (Table 4). Such changes one can explain by the fact that the croplands were one of the main fragmentation elements in 2001. Eventually, these lands were abandoned due to the overgrowth process by natural vegetation, that’s why this class became the less fragmented and more aggregated.

The most common forest type within the investigated territory is mixed forest [55]. During 12 years the number of patches decreased by 6, while the percentage of adjacency became sufficiently high (PLADJ 2001 – 75.89 %, PLADJ 2013 – 81.29 %) just like the Aggregation Index. This class has the greater effective mesh size (MESH) that doesn’t depend on the number of patches. Also, it has minimum splitting and high aggregation that indicates on significant level of West Polesie mixed forests homogeneity (Table 4).

Table 4

Changes in the landscape metrics of class level for the period of 2001 to 2013

Class/Metrics	CA, ha	NP	LSI	PLADJ, %	IJI, %	COHESION, %	MESH	SPLIT, ha	AI, %
Water bodies	↑**85,86**	↓3	↓0,29	↑**3,11**	↑**9,35**	↑**2,19**	↑**1,67**	↓2781,78	↑**3,18**
Evergreen needleleaf forest	↓4293,20	↓72	↓2,97	↑**3,32**	↑**6,6**	↓1,14	↓12,27	↑**8281,14**	↑**3,69**
Evergreen broadleaf forest									
Deciduous needleleaf forest	↑**708,38**	↑**18**	↑**2,89**	↑**1,37**	↑**13,68**	↑**18,54**	↑**0,13**	↓8489032,55	0
Deciduous broadleaf forest	↓1159,16	↓60	↓3,67	↑**12,76**	↓17,25	↑**22,98**	↑**0,16**	↓271293,65	↑**14,82**
Mixed forest	↑**12450,09**	↓6	↓3,14	↑**5,4**	↓19,74	↑**0,46**	↑**13975,40**	↓7,92	↑**5,42**
Closed shrublands									
Open shrublands	0	0	0	0	↑**0,63**	0	0	0	0
Woody savannas	↓6611,50	↓178	↓9,50	↓10,90	↑**13,17**	↓15,48	↓1,67	↑**220460,16**	↓10,98
Savannas	↓1652,88	↓69	↓7,22	N/A	↓32,77	0	↓0,15	↑**184003615,83**	N/A
Grasslands	↓665,44	↓35	↓2,76	↑**9,39**	↑**5,63**	↑**13,86**	↓0,04	↑**1397591,96**	↑**11,95**
Permanent wetlands	↑**1846,07**	↑**35**	↑**3,90**	↑**13,18**	↑**8,47**	↑**22,76**	↑**0,60**	↓6184995,49	↑**12,64**
Croplands	↓33121,92	↓63	↓6,33	↓0,07	↓17,2	↓5,49	↓627,34	↑**940,75**	↑**0,41**
Urban and build-up lands	0	0	0	0	↑10,73	0	0	0	0
Cropland/natural vegetation mosaics	↑**32885,62**	↓131	↓6,37	↑**16,20**	↓0,74	↑**5,27**	↑**6175,05**	↓204,58	↑**16,27**

Among other forest types, the most territory is occupied by the evergreen needleleaf forests – 17 108 ha in 2001 and 12 815 ha in 2013. One can observe the minor changes in their structure and spatial distribution. The number of patches is decreased by 72. At the same time, their cohesion varies from 67 to 68 % and LSI is near 15 %.

Open and closed shrublands occupy the insignificant area (≈ 0.01 %). Moreover, in 2013 the closed shrublands disappeared from the land cover (Table 4). The effective mesh size for shrubs is actually equals zero. The Interspersion Juxtaposition Index (IJI) averages 52 % that indicates an unexpressed localization the shrub class fragments within the landscape.

A considerable reduction of the savannas did not lead to substantial changes in landscape metrics of this class, except the increase of SPLIT Index during years (Table 4). One can explain the aforesaid by small areas of this class. Besides, the fragments of this class often consist of one mesh.

Speaking on the grasslands, one can see the decrease of the area and the number of patches during 2001–2013 along with two-hold increase of the SPLIT Index.

The expansion of permanent wetlands is characterized by corresponding increase of the number of patches by 35. The effective mesh size increased by 0.6 ha, and Aggregation Index by 12.64 %. At the same time, the IJI Index decreased by 10 % (Table 4). Such changes of indices are the evidence of increasing both wetlands area and separate wetland massifs with more even distribution within the TBR territory.

Water bodies also have undergone some changes: the area increased by 85.86 ha and the number of patches decreased from 10 to 7, because of draining the small lakes and ponds, being separate elements of this class. This land cover is characterized by high cohesion of class fragments that equals 82 %. Analyzing the features of the fragments distribution of this class, one can take into account three water objects within the TBR territory, namely: Svitiaz, Pulemetske and Liutsymer Lakes (Fig. 1). These largest water bodies considerably influence the calculations of this class landscape metrics.

Considering the croplands, one can see four times smaller MESH Index caused by lands reduction. At the same time the cohesion of fragments stayed on maximum level and equals 84–89 %. An average percentage value of the class adjacency did not change and equals 61 %. The same meaning has the AI. The LSI decreased from 21.6 to 15.3. All the above-mentioned indicate the increase of croplands homogeneity, aggregation and compactness.

Actually, the urban and built-up lands during the 12-years period did not change and occupy approximately 1 525 ha. This class has significantly high level of cohesion – 72.9 % what is typical for it. Distribution of the fragments within the landscape is sufficiently even what can be demonstrated by the following indices: PLADJ – 56.34 %, AI – 64 % and IJI – 49.48 %

Conclusions

Methodical approaches to the landscape diversity analysis using the landscape indices (Shannon's and Simpson's Diversity/Evenness Indices) and satellite data were applied for the first time in the West Polesie Trilateral Transboundary Biosphere Reserve territory. This allowed defining the significant changes in landscape structure of the Biosphere Reserve during 2001–2013 both on the landscape level and on the level of separate classes of land cover.

It was determined that for the 12-year period the decrease of the areas with maximum values of diversity and the increase of homogeneity of the investigated territory took place.

It is shown that landscapes, forming the WP TBR territory undergone the most significant changes on the level of separate classes. One can see the increase of general percentage during 2001–2013 of all forest massifs, in particular: increase of mixed forests area due to overgrowth of savannas and woody savannas. Declination and overgrowth the croplands, reduction of melioration works and restoration the natural complexes within the Biosphere Reserves have resulted in the increase of areas with natural vegetation mosaics and, accordingly, the permanent wetlands.

Results of current research are used in the management decision-making about the activities on preservation of biological and landscape diversity and, also for expansion the recreation potential of the above-mentioned territory.

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