CONSTRUCTIVE GEOGRAPHICAL MODEL OF THE LAKE-BASIN SPECIALIZED RECREATIONAL SYSTEM (ON THE EXAMPLE OF THE LAKE OSTRIVSKE, UKRAINIAN POLESIA)

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Abstract: The question of the development of the lake basin system (LBS) model with the recreational oriented use is further discussed (take the example of the Ostrivske Lake, Ukrainian Polesia). The proposed LBS model is constructive geography by the content. It is presented by the lake depression bathymetric map, landscape-geographical maps of the water body, as a natural aquatic system, and different ranks of the natural territorial complexes of watershed. The tables illustrate the main limnological and landscape metric parameters of the basin system. The main directions of the recreational use of the Ostrivske LBS are grounded in the context of the sustainable natural resource management of the local areas.

Keywords: lake, lake-basin system (LBS), model, natural aquatic complex (NAC), natural territorial complex (NTC), recreational natural resource management

Introduction:

Ukrainian Polesia is one of the richest for the country's regions of water bodies. According to the researchers, there are 3,429 slow flow water bodies (SFWB) with a total area of 56,394.29 hectares, which is 0.51% of the whole water resources of Polesie region (Ilyin 2011). The presence of significant resource potential of the SFWB actualizes the problem of its rational use and protection.

A special place among SFWB of Ukrainian Polesia occupies the lakes, as a

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Department of Ecology and Sustainable Environmental Management Rivne State Humanitarian University Art. S. 12 Street, Rivne 33028 Ukraine e-mail: Martynyuk_RIS@mail.ru kind of natural aquatic complex (NAC). The formation and development of the lakes are influenced the geological, bv meteorological, geomorphologic, hydrological, biotic and anthropogenic factors. Therefore, we consider the lake landscape genesis in paragenetic and paradynamic unity with its watershed and geo-ecological processes within it, and its natural holistic (natural household) formation that we call lake-basin system (LBS).

An important direction of the use of Ukrainian Polesia lakes can become its application as recreational management. Throughout the region, with the extreme regional clusters of lakes and wetlands, a number of environmental and recreational areas have been created. Some of them have an international status. Here we should mention the Shatsky National Nature Park, which is a part of transboundary Biosphere

Reserve West Polesie, as well other national parks as Pripyat-Stokhid, Mezynskyy, Desna-Starogutskiy, Ichnyansky and a number of regional landscape parks. Many national and regional landscape parks, lakes and LBS mainly are a kind of recreational nodes (or cores) that attract great amount of tourists. Therefore it is relevant to develop constructive-geographical models of LBS recreational specialized orientation (Martynyuk 2012). These types geographic models are also needed for hydrological, land reclamation, tourist, environmental, cultural and educational institutions and organizations.

Materials and methods:

The study is based on field expedition landscape limnological search, which have been conducted by the author within the Ukrainian Polesie for about 20 years. We have been conducting bathymetric instrumental measurements. We have been studying the hydrological regime thermal features of the lakes, the lithological compound and bottom sediment layers of water bodies and their geochemical differences. During the summer period we have explored the biotic condition of the lakes, in particular the species' composition of macrophytes and single floating algae underwater plants. A separate block of the searches consisted of landscape studies conducted within the watershed lakes. We have laid the ground cuts and the microcatenary landscape in the lake basins. We have selected the profile of the soil samples, identified the species composition of plant communities etc. We have diagnosed and analyzed the field data obtained during the expedition searches in the certified laboratories (Rivne Branch of State Institution Soil protection institute of Ukraine, Rivne Regional Hydrometeorology Center).

The direct methods of our research were scientific works of constructive geography and landscape (Petlin 2006, 2010), complex

physiographic studies (Beruchashvili and Zhuchkova 1997), cartographic modeling (Tikunov 1997), Limnology (Yakushko 1981) and Geoinformatics (Svitlychny and Plotnytskyiy 2006), as well as personal exploring experience of many LBS of Ukrainian Polesie (Martynyuk 1998, 1999, 2011a). There were involved partial materials of Kyiv and Rivne geology-exploring expeditions (KGEE and RGEE), related to the composition and geochemical characteristics of the lake sediments and pre quaternary geological structure.

A notable place among SFWB of Ukrainian Polesie is held by a group of lakes of the Ostrivske Hydrological Reserve, which is located in the western part of Ukraine (Martynyuk 2011b). It is four lakes that have compactly formed here, namely Ostrivske, Velyke, Serednie and Horomne. The latter three lakes are part of the hydrological reserve, whilst Ostrivske Lake is used for recreational purposes. The lakebasin system of the Ostrivske Lake is located on the main trail of the tourist route created by us, Blue Western Polesie Pearls, with a total length of over 100 kilometers (Martynyuk 2011c). Therefore, we consider Ostrivske LBS as an important recreational hub in the metioned tourist route.

The purpose of the article is to reveal the nature and characteristics of the structural and geographical model of the specialized recreational lake type (for example Ostrivske LBS, Ukrainian Polesie) for the purposes of sustainable nature management of the local areas.

Ostrivske LBS is located in the interfluve of Veselyha and Nozyk located in Nyzhnostyrsk Volyn Polesie landscape (Fig. 1). Ostrivske LBS is geographically confined to the swampy river-plain areas featuring ancient fluvioglacial and alluvial deposits. From the tectonic angle, the study area is interesting because this is the southern boundary of Stohidsko-Mogilev tectonic mantle lying zone (Zalessky 1999).

Ukrainian Polesie landscapes, namely Ostrivske LBS, underwent greening in the Pleistocene, including the most powerful Dnieper glaciation. During the low-lying glaciation, the territories were characterised by supraglacial accumulation zone of melted ice water in the large lake basins and streams

which delayed a lot of sandy material. Under the influence of glacial thawed water in the lower sections of the bog-lake, there formed the natural-territorial complexes (NTC).

Figure no. 1 Outlines the place of the Ostrivske Lake basin on the map in Central and Eastern Europe (left) and the physical and geographical regionalization of Volyn Polesie (right) (after Marynych et al. 2003), with the specification of Verhnopryp'yatskyy Eastern District limits (after Martynyuk 2010)





Note: Landscape areas: 1. Verhnopryp'yatskyy; 2. Nyzhnostyrskyy; 3. Lyuboml-Kovel; 4. Manevitskiy-Volodymyrets; 5. Kolkivsko-Sarny; 6. Turiysk-Rozhyshchenskyj; 7. Kivertsivskiy-Tsumanska; 8. Kostopil-Bereznovsky.

Results and discussion:

Ostrivske Lake displays an irregular oval shape and is elongated from the north-east to the south-west of the island in the southern part (Fig. 2).

The slopes of the lake basin are quite steep, whereas the bottom is sandy. There is a clearly slightly indented coastline. The coastal strip is covered mostly with meadow grasses, pine, alder, and occasionally birch. In the winter of 2013-2014 we conducted the bathymetric profiling of laying the nine hydroislands with ice water surface. Wells were made in ice at every five meters, with the help of the hammer drill.

According to the results of the hydrographic profiling of the lake, using high-resolution satellite imagery and software MapInfo 7.5, firstly by us, the bathymetric design of the map of Ostrivske

Lake was constructed (Fig. 3, Annexes). On the bathymetric map isobaths are drawn within each meter, color shades show changes of the depths. Additionally, we have decoded thickets of higher aquatic vegetation in the littoral zone of the lake.

The lake's water surface square, according to our estimates, is 1.08 km² (or 108,227 ha). The lake is drainless. The water is 1.9 km length, its maximum width is 0.8 km (Tab. 1) of the water body, whereas the coastline is 4.75 km. The maximum water depth reaches 10.5 m, and the average, 6.2 m. The capacity of the lake's water masses is 6844.8 m³. Instrumental field studies, combined with measurements on the map, allowed us to create a complete parametric block of Ostrivske Lake. A more detailed approach of the limnometric characteristics is displayed in Table 1.

Figure no. 2 Localization of Ostrivske Lake





Note: a. view from the space (limits are shown by yellow tint settlement - source: Google Map); b. panorama with island image.

Table no. 1 Morphometric and hydrological parameters of the lake basin Ostrivske

F*,	H _{abs.} ,	h _{mid.} ,	h _{max.} ,	L,	$W_{max.}$	$W_{mid.}$	1,	C	C
km ²	m	m	m	km	km	km	km	C _{c.}	C _{len} .
1.08	145.4	6.2	10.5	1.9	0.8	0.59	4.75	0.73	3.22
C _{cap.}	C	C	V _{mas.} ,	Ţ	ΔS,	${ m W_{inf.,}}^{**}$	0	Λ ο	$A_{lev.}$
	C _{op.}	$C_{\text{dep.}}$	th.m ³	1	km ²	th.m ³	$a_{\text{wat.}}$	Δ a _{wat.} ,	mm
0.59	0.17	6.02	6844.8	0.34	2.96	136.24	0.020	50.24	214.0

Note: * Lake`s square footage (F), absolute height of the sea level ($H_{abs.}$), middle depth ($h_{mid.}$), maximum depth ($h_{max.}$), length of the water body (L), maximum width ($W_{max.}$), middle width ($W_{mid.}$), length of the coastline of the lake (l), coefficients: of coastline cutting ($C_{c.}$), of the lake lengthening ($C_{len.}$), of capacity ($C_{cap.}$), of openness ($C_{op.}$), of the depth ($C_{dep.}$), the volume of water masses ($V_{mas.}$), area index (I), specific volume (ΔS), volume inflow ventilation pipes water from the catchment ($W_{inf.}$), conventional water exchange ($a_{wat.}$), specific water exchange ($\Delta a_{wat.}$), assimilation level ($\Delta A_{lev.}$); ** The average annual runoff module dm³ / s km² - 4.0.

In order to create a landscape-mapping model of the lake such as NAC, it is important to clarify the lithology of the bottom sediments, their power geochemical characteristics. According to Kyiv GEE, the maximum sapropelic layer deposits are 8.7 m, the average being 3.6 m. Therefore, the maximum depth of the lake basin, taking into account the maximum water depth, is 19.2 m. An analysis of geological drilling data of RGEE shows that starting from 20 meters of depth (125.4 m above the sea level, from now on a.s.l) from the earth's surface, within the catchment area

of the lake, lay sandy-loamy calcareous sediments (which, apparently, stands for the mudding area). Further, starting from 27.0 m from the water's edge (or 118.4 m a.s.l.) lays writing chalk K₂t. These geological features of pre-quaternary structure of Ostrivske Lake provide reasons to mention that there is infiltration connection between the lake and the water-soluble K₂t horizon. We believe that these karst-denudation processes have played a dominant role in the formation of the lake basin, and play the same significant role in feeding the water bodies which are around it as precipitation today.

Bottom sediments of the peripheral part of the water body are represented by sandy, sandy-silt and peat marsh deposits. The thickness of pelogen is 0.1-0.2 m. Sapropel square, according to KGEE, is 63.8 hectares. Deposits are mostly represented by carbonate-algal sapropel and their varieties. The stocks of sapropel are 2296.8 m³ with natural moisture of 88.6%, and in recalculation in conditional 60.0% humidity are 700.4 thousand tons.

For the analysis of some sapropel geochemical parameters (Fe₂O₃, CaO, pH) we oriented ourselves according to data from the peaty exploratory laboratory of KGEE. Geochemical features of sapropel on one of the sensing points have the following characteristics:

- the maximum concentration of Fe_2O_3 up to the depth of 0.20-0.50 m is 3.25% (% on the dry matter), and minimum as far as the depth of 6.5.0-7.0 m (1.56%) is concerned. The average concentration of Fe_2O_3 typical of the whole profile is 1.63-1.90%.
- the natural concentration of iron compounds depends on those geochemical environments that were formed at a certain stage of sedimentation of the lake sediments.
- regarding the concentration of CaO (% on the dry matter), the largest content of its compounds observed in the samples in the depth of 4.5-5.0 m 3.03%, and the lowest 1.09% in the depth of 7.0-7.5 m. The average concentration of CaO is 1.42-1.72%.
- acidity or fluid and electrolyte balance of the sapropelic deposits ranges between 4.77 medium-acid reaction (depth 5.0 m) to weak-acid reaction 5.40 (8.5 m). In general, for most samples at this point of sensing, sapropel have weak-acid reaction of water-salt balance.

The aquatic vegetation develops mainly along the northern shore of the lake and is represented by reeds, cattail and spiny rush.

Out of the single floating plant leaves, there are the white lilies and yellow jugs with the underwater vegetation dominated by cabomba, with the subordinate spread of stratiotes and developed arrowhead. The percentage of the lake's overgrown bottom vegetation is about 10.0%.

The achieved results of the bathymetric measurements, capacities and varieties of lake sediments and distribution of chemical elements in geological structures, species' diversity of surface and underwater vegetation water bodies were involved in the drafting of landscape models of the lake NAC, including differentiation of their facial landscape structure structure. The Ostrivske Lake NAC is quite diverse in its composition (Fig. 4, Annexes). Within the lake, as a complex aquatic ecosystem, we have identified three local NAC (rank pidurochyshche) and an island local NTC (rank urochyshche). The littoral sublittoral local NAC (rank pidurochyshche) are represented by four aquatic facies, whilst the sublittoral and profundal zone with two varieties of facies. In the island local NTC there are founded two types of terrestrial facies. Settlements and other areas' metric characteristics of the NAC of the lakes are conveyed in Table 2.

The largest square (over 40%) of the NAC include sublittoral local NAC (rank pidurochyshche), rendered bv limestone (23.6% of the area) and claylimestone (about 18.0% of the area) varieties aqua facies. The second place occupies the littoral-sublittoral local NAC (rank pidurochyshche) (about 37%), its facial structure being a mosaic displaying 17 sections. This local **NAC** pidurochyshche) is undergoing a significant anthropogenic impact from the economic activity of Ostrivsk village, which surrounds the southern part of the lake in a horse-shoe Profundal local NAC urochyshche) (about 22% of the area) is relatively deep. It occupies the central part of the lake bed basin and has four landscape sections. The island upland is small by its area (1.2%).

NAC (NTC) View		NAC (NTC) Vies Square (ha)		% type area of the total area		r of contours ies within the NAC	% of total	average area of bid) urotshistshe (he)	Index of dissemination	Index of complexity	Index of landscape dissemination
Local NAC (NTC)	Facie	Local sNAC (NTC)	Facies	Local NAC (NTC)	Facies	Number of type facies	%	The ave the (pid)	In	Index of	Index o
I		39.869		36.84							
	1.1		1.895		1.75	4	15.38	0.47	2.11	8.51	0.75
	1.2		3.218		2.97	6	23.08	0.54	1.86	11.11	0.83
	1.3		17.669		16.33	5	19.23	3.53	0.28	1.42	0.80
	1.4		17.087		15.79	2	7.69	8.54	0.12	0.23	0.50
II		45.029		41.61							
	2.1		25.586		23.64	2	7.69	12.79	0.08	0.16	0.50
	2.2		19.443		17.97	1	3.85	19.44	0.05	0.05	0.00
III		21.993		20.32							
	3.1		10.119		9.35	1	3.85	10.12	0.10	0.10	0.00
	3.2		11.874		10.97	3	11.54	3.96	0.25	0.76	0.67
IV		1.336		1.23							
	4.1		1.170		1.08	1	3.85	1.17	0.85	0.85	0.00
	4.2		0.166		0.15	1	3.85	0.17	6.02	5.88	0.00
Total	•	108.227	7 108.227	100.0	100.0	26	100.0	4.16	0.24	6.25	0.96

Table no. 2 Difficulty of territorial dismemberment of the lake Ostrivske NAC

Nearly 1.1% of the area tract occupies flat-top eluvial facies. In general, in NAC of Ostrivske Lake we identified 26 landscape sections. Other characteristics of the territorial dismemberment of NAC of the lake are presented in Table 2.

The second block of structural and geographical modeling LBS is associated with the analysis of the landscape structure and spatial-typological characteristics of the catchment area of Ostrivske Lake. The basin

area of the lake is 3.20 km² (Tab. 3). In the structure of the lands, about 34% is occupied by the lake, about 20% is occupied by the forest, wetlands make up 10%, almost 24% is featured by arable lands and about 13% are employed for building in village Ostrivske. Thus, the rate of economic development of the catchment is 57.64%. More options for the watershed lands are shown in Table 3.

Table no. 3 Structure of the lands of Ostrivske Lake catchment, calculated out of the maps

S, km ²	P, km²	m	Land area										S _{pros} ./
			F		f _{in.}		m _{in.}		a _{l.}		$\mathbf{r}_{\mathrm{l.}}$		$S_{n.pros.}$
			km ²	%	km ²	%	km ²	%	km ²	%	km ²	%	_ % ¹
3.20	7.81	1.23	1.08	33.75	0.63	19.69	0.32	10.0	0.76	23.75	0.41	12.81	57.64

Note: Square of the catchment area (S), perimeter of the catchment area (P), coefficient of the catchment line (m), forest idex ($f_{in.}$), marsh idex ($m_{in.}$), arable lands ($a_{l..}$), residential lands ($r_{l..}$); $S_{pros.}$ (%) - indicator of economic development of the catchment.

According to the results of the field studies, we compiled the landscape map of the Ostrivske Lake catchment (Fig. 5). Within the basin of the lake, we have identified NTC seven local urochyshche) an aquatic natural and boundary of the lake basin. The local NTC of hills and dunes, as well as areas of high interfluves (Section 1-2) have a higher hypsometric level, being more resistant to natural and anthropogenic transformations.

Wetland depressions local NTC undergo significant changes in the landscape and succession. On the other hand, they serve an important hydrological role in stabilizing the basin system. The northeastern part of the catchment area adjacent to the lake (especially 7) is undergoing eutrophication. In the future, the lake area will decrease it on this site, as in littoral zone here peat bog deposits with thickets of reed-sedge communities is outweighing.

Conclusions:

Analyzing the results of the research, we came to the following conclusions:

- System - Ostrivske Lake Basin includes two landscape-geographical models, namely NAC of the lake and its catchment NTC of different parametric levels. Maps and characteristics of LBS are presented in the tables and can be considered as a source (of reference or base) to design circuits of recreational nature basin area.
- hydrological morphometric lake parameters are favorable for the development of beach-bathing holiday, diving, sailing, rowing, and amateur fishing. In winter the tourist can do skating and ice-board sports. The aesthetic potential of the lake is also favorable for video and taking pictures.
- Lake Basin has become a recreational hub within the tourist

- routes Polesie Lake District and Western Polesie Blue Pearls. Within the catchment it is advisable to build a shelter and recreational point allotted to Rental Equipment. Based on the model of recreational node, it is needed to develop a clear list of ecosystem services (procurement, regulatory, cultural, supportive, informational) to facilitate the development of ecological tourism.
- for the regional authorities, primarily the Department of Culture and Tourism of the Rivne Regional State Administration, Local Government (Ostrivske Village Council) it is important to develop a number of constructive measures for sustainable improvement of recreational use of Ostrivske Lake. The Lake Basin system is favorable for such aspects as health, medical, sporting, scientific, cognitive one etc., also for recreation.

Rezumat:

MODEL GEOGRAFIC CONSTRUCTIV
PENTRU BAZINUL DE LAC
SPECIALIZAT CA SISTEM
DE AGREMENT
(EXEMPLIFICARE PE
LACUL OSTRIVSKE,
REGIUNEA POLESIA DIN UCRAINA)

În studiul nostru este prezentată problema dezvoltării unui model pentru un sistem lacustru (LBS), în vederea folosirii în domeniul agrementului (exemplificare pe lacul Ostrivske din Regiunea Polesia din Ucraina). Modelul LBS propus geografic constructiv prin caracteristicile proprii. Acesta este prezentat prin harta batimetrică depresionară, hărțile peisajului geografic al bazinului lacului ca sistem acvatic natural, precum și diferite nivele ale complexelor teritoriale naturale din bazinul hidrografic. Sunt prezentați principalii parametri limnologici și geografici ai sistemului lacustru. Principalele direcții de folosire a lacului Ostrivske ca LBS pentru agrement sunt fundamentate pe gestionarea durabilă a resurselor naturale din zonă.

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Annexes:

Figure no. 3 Ostrivske Lake bathymetric map (reduced with 1: 5000)

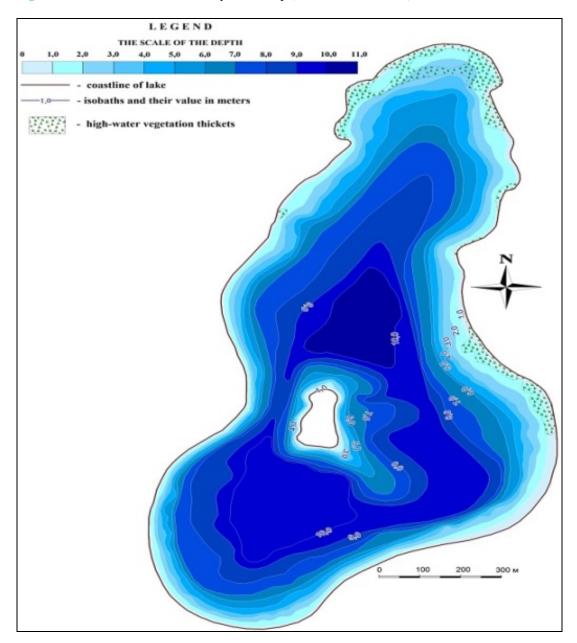
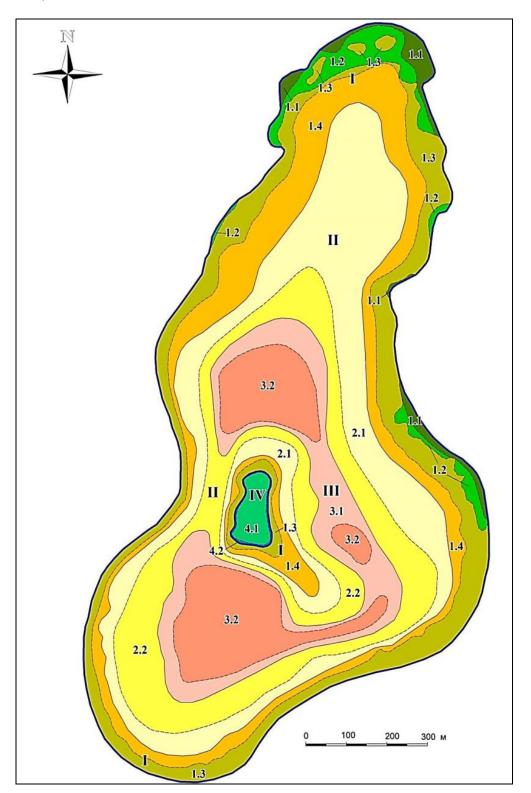


Figure no. 4 Landscape structure of natural aquatic complex of the lake Ostrivske (reduced to 1: 5000)



LEGEND

 Littoral-sublittoral aqua pidurotshistshe on sandy, sandy-silt and peat bog sediments, formed on alluvial sands with species diversity of surface and underwater macrophytes.

Aquatic Facies:

- Shallow, marsh accumulative, reed-sedge associations with homogeneous temperature conditions.
- Shallow, peat-bog accumulative, typha-juncus associations with homogeneous temperature conditions.
- 1.3 Shallow, abrasion-accumulative sand-silt, nymphaea-stratiotes-sagittaria sparse associations with homogeneous temperature conditions.
- Shallow, sandy transit-accumulative, elodea-potamogeton sparse associations with homogeneous temperature conditions.
- II. Sublittoral aqua pidurotshistshe on algal carbonate sapropelic, formed on alluvial sands with species diversity of freely floating and underwater vegetation.

Aquatic Facies:

- 2.1 Sublittoral, transit-accumulative calcareous-algal sapropelic medium layer (1,5-3,0 m) ceratophyllum-lemna associations with the small temperature amplitude in summer.
- Sublittoral, accumulative-transit clay-limestone sapropelic medium layer (3,0-4,5 m) chara-filamentous associations with the small temperature amplitude in summer.
- III. Profundal aqua pidurotshistshe of the lake bed central basin on organic-clay-limestone and calcareous sapropelic, formed on the calcareous loam with sparse species diversity of underwater vegetation.

Aquatic Facies:

- 3.1 Profundal, transit-accumulative organic-limestone sapropelic heavy layer (4,5-6,0 m) with lean underwater vegetation and single floating algae, with the small temperature amplitude in summer.
- Profundal, clay-limestone accumulative sapropelic heavy layer (6,0-8,7 m) of the single floating algae with the small temperature amplitude in summer.
- IV. Island slightly raised urotshistshe, covered with arbutus- green bryophyte birch-pine-alder groups on hidden sod-podzolic gleyey, and sod gley sandy and sandy loam soils.

Facies:

- 4.1 Flat island eluvial birch pine associations on hidden sod-podzolic sandy soils.
- Slope island transeluvial motley grasses-sedge-alder associations on hidden sod-podzolic gleyey sandy and sandy loam soils.

Borders:

- complicated natural-aquatic complex;
- ------ urotshistshe;
- ---- facies and aquatic facies.

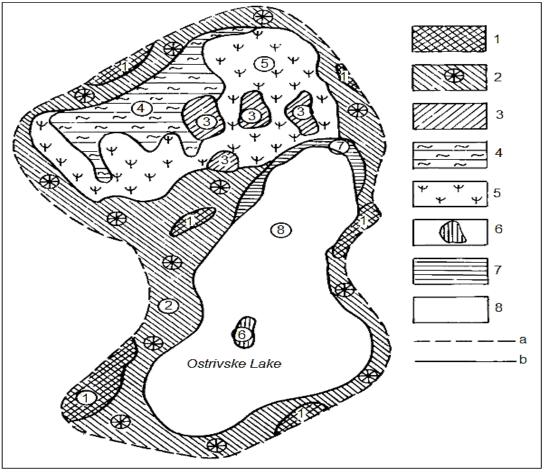


Figure no. 5 Landscape structure Ostrivske Lake catchment (M 1:25 000)

Note: 1-7: local NTC (rank urochyshche); 8: complex aquatic system; boundaries: a - of the catchment, b - of the local NTC.

Legend: 1. Gibbosity and dunes with slightly retreating (5-10°) slopes covered with lichens, pine forests, undershrubs, implicitly podzolic sometimes with rubble, sandy soils; 2. Elevated areas' interfluves complicated by karst funnels, with gentle slopes (3-5°) covered with lichens, arbutus, green pines, birches and pine forests on podzolic, sometimes gleyey, sandy soils under cultivation and partly built; 3. Local uplift, with slightly inclined (<3°) slopes covered with brackens, blueberry, birches, pines and oaks, birches and pine forests on sod-podzolic sandy soils gleyey, sometimes under cultivation; 4. Wavy areas of the interfluves covered with brackens, blueberry, green bryophytes, birches, pines and alders groups on hidden sod-podzolic gleyey, and sod gley sandy and sandy loam soils, sometimes under cultivation; 5. Extensive wetlands lowering are covered with cottongrasses, peat mosses, undershrubs, motley grasses, green bryophytes and sedges, alders, birches, alder woodland on meadow, marsh and shallow marsh soils; 6. Lake islands of prominent peaks are covered with buckthorns, green bryophytes, oaks and pine forests on sod-podzolic gleyey turf, sandy and sandy loam soils; 7. Lacustrine narrow relegation, which is filled with water during the floods, is covered with reedmace, sedges, forbs, undershrubs, alders, willows, thatched and undergrowth layered on meadow gley sandy and sandy loam soils; 8. Lake basins with elongated form in the littoral zone are covered by reedmace, rushes and water-lilies association, and in sublitorall areas and profundal there are single floating algae on the sapropel deposits.