Landscape structure of the territory of the State nature sanctuary of regional significance "Sursky Peaks" (Ulyanovsk region, Russia)

A E Astashin¹ ², M M Badin¹, I Yu Krivdina¹, O E Vatina¹ and O N Pashkin¹

¹ Kozma Minin Nizhny Novgorod State Pedagogical University (Minin University), 1, Ul'yanova, Nizhny Novgorod, 603950, Russia
² Nizhny Novgorod state engineering and economic university, 22a, Oktyabrskaya St., Knyaginino, 606340, Russia

E-mail: astashinfizgeo@yandex.ru

Abstract. The article presents the results of landscape differentiation of the territory of the state nature sanctuary "Sursky Peaks" (Ulyanovsk region), performed at the hierarchical level of landscape types. The researched territory is located in the forest-steppe zone (northern forest-steppe subzone) within the Volga upland. The territory is characterized by high biological diversity. The high environmental significance determines the relevance of the landscape zoning scheme, which is necessary for the effective organization of environmental and recreational activities. During the research, 4 landscapes were identified, for each of which a list of characteristic stows was established, areas of violations of the environmental regime – clearings – were identified and mapped. The work was carried out on the basis of field researches, conducted in 2021, materials of remote sensing of the Earth, thematic maps, literary data processed using GIS.

1. Introduction

Specially protected natural territories perform environment-forming and environment-stabilizing functions, which ultimately provides the ecological, economic and social basis for the existence of mankind. Landscape analysis of natural-territorial complexes is the key to understanding the patterns occurring in the typological and biogeocenotic structure of natural ecosystems of any rank [1]. Landscape structure and landscape features are one of the most important conditions for optimal territorial planning, management, as well as investment in the economy of the territory [2-4]. Currently, the schemes of landscape zoning of territories at the level of landscapes and stows, including for solving environmental and recreational tasks, have been implemented only for certain few territories [2]. There is no such scheme for the territory of the Sursky Peaks state nature sanctuary, although the need for it, due to the high scientific and environmental significance of this protected area, as well as intensive recreational use, is obvious.

2. Materials and methods

The purpose of the research: to develop a scheme of landscape differentiation of the territory of the state nature sanctuary "Sursky peaks".

The object of the research: the territory of the state nature sanctuary "Sursky peaks".
Subject of the research: landscape structure of the territory of the state nature sanctuary "Sursky peaks".

Landscape researches is an interdisciplinary category and a subject of research in many different fields. Landscapes are typed, characterized and mapped in accordance with the tradition of landscape material, based on natural sciences at the first stage, and stakeholders of all kinds can be invited to an open process of landscape assessment and development of management strategies and policies at the second stage of landscape analysis [5].

3. Results
The presented work is based on the results of field research, conducted by the authors on the sanctuary in 2021. In the course of the research work, the following research methods were applied: expeditionary, descriptive, cartographic, geoinformation, analysis of literature and stock materials, statistical, remote researches, complex physic-geographical (landscape) analysis, comparative geographical, geographical zoning. Generalization and spatial analysis of the data were carried out, using the geographic information system Quantum GIS. The state nature sanctuary "Sursky peaks" is located in the forest-steppe zone (northern forest-steppe subzone) within the Volga landscape region [6].

Pre-quaternary formations are represented by sediments of the Paleogene system (clays, opoka, sands, sandstones, trepels), small-contour areas are scattered with areas of distribution of Neogene sediments (sands, loams, boulders, rubble, gravel, pebbles) [7]. The cover of Quaternary sediments is represented by eluvial-deluvial deposits of the Neopleistocene (loams, clays, sands), rocks of pre-Quaternary age are exposed on watersheds, alluvium on floodplains of streams, and proluvium in ravines [8]. The following geological processes have been developed: linear erosion (ravine formation), deluvial flushing, local waterlogging.

The amplitude of the heights is 137 m, the maximum mark is located in the west of the sanctuary on the plakor, the minimum – in the southeast – the water's edge in the Almayka river. A variety of relief forms are presented within the sanctuary: a plakor, a slope, a dune, an inter-dune depression, a beam, a furrow, a pothole, a ravine, a floodplain of a small river.

The most notable object of the hydrographic network of the sanctuary is the up-stream of the Sura River. In addition, small rivers and streams originate here – Pospelovka, Almayka, Saiman-Busa, Izen-Sirma, Nemchurka, Black River, Burnt Bridge, Drachaleika. There are several unnamed springs. A large hydrological object is the lake Svetloe in the center of the sanctuary. In 500 m north-east of the lake is the Makhovoye-Nikulinskoye swamp, which is an epilimn – post-lake swamp formation; in addition to it, there are a number of similar smaller swamps in the northern part of the re sanctuary.

Gray forest soils are common in the northern part of the sanctuary, sod-podzolic soils in the southern part, alluvial-sod soils on floodplains of rivers and streams, ravine-balka complex soils in ravines and balks, peat-swamp soils in swamps.

In the course of field research descriptions of typical stows were carried out. Based on the analysis of thematic maps, data from remote sensing of the Earth and field research, a scheme of landscape zoning of the territory of the state nature sanctuary "Sursky Peaks" at the hierarchical level of stows and landscapes was compiled (figure 1).

In the course of landscape and geobotanical researches in the summer field season of 2021, a floristic list was compiled, including 172 plant species in 64 families of 7 classes, which is evidence of the high biodiversity of the researched territory and confirms the expediency of its conservation status. Below is a list of landscapes of the state nature sanctuary "Sursky Peaks" and the stows in their composition. The watershed easily moistened dune-bumpy forest landscape under pine forests on sod-podzolic soils covers the central part of the state nature sanctuary "Sursky Peaks", extending from north to south. The lithogenic basis of the landscape are sands, sandstones, opoka and clays of Paleogene age, coming to the surface, or overlain by a low-power thickness of eluvial-deluvial undifferentiated deposits of the Neopleistocene (sands, loams, sandy loam ). Modern geological processes are
represented by deluvial flushing, waterlogging occurs locally. The relief is gently sloping, represented by plateaus and watershed slopes, complicated by dunes, runnels and the tops of ravines. Hydrographic objects are represented by the lake Svetloe and a complex of marshes on watersheds. The soil cover formed on the eluvium of pre-quaternary rocks is represented by sod-podzolic soils. The vegetation cover, represented by mixed and pine forests, has been and is being cut down, on the site of which pine crops have been planted and are being planted, or there is a natural overgrowth of pine wastelands with birch and aspen trees, under which pine forests are being restored.

Stows:

- Flat-humped plain under the pine communities on sod-podzolic soils.
- Gently undulating plain under the pine culture on sod-podzolic soils.
- Gently undulating plain under the restoration of pine communities on sod-podzolic soils.
- Lake terrace under the birch open woodlands with the community of southern reed and sphagnum on peat-swamp soils.
- Gently undulating plain under the community of the pine forest wasteland on sod-podzolic soils.
- Gently undulating plain under the birch communities on sod-podzolic soils.

The sloping easily moistened forest landscape under coniferous-small-leaved forests on sod-podzolic soils borders the watershed easily moistened dune-bumpy forest landscape under pine forests on sod-podzolic soils. The lithogenic basis of the landscape is sands, sandstones, opoka and clays of Paleogene age, coming to the surface, or overlain by a low-power thickness of eluvial-deluvial undifferentiated deposits of the Neopleistocene (sands, loams, sandy loams). In ravines and balkas – proluvial and deluvial deposits. The relief is complicated by ravines, balkas, deluvial trains, and removal cones. The objects of the hydrographic network are represented by the sources of small rivers and streams. The soil cover is represented by truncated gray forest soils on loam, sod-podzolic – on sand. Vegetation is represented by pine forests and pine crops, linden trees and secondary small-leaved forests, less often – oak forests, maples.

Stows:

- Flat-humped plain under the pine communities on sod-podzolic soils.
- Flat-hilly plain under the pine culture on sod-podzolic soils.
- Gently undulating plain under the restoration of pine trees on the pine forest wasteland on sod-podzolic soils.
- Gently undulating plain under the birch community on sod-podzolic soils.
- Gently undulating plain under the restoration of linden on gray forest soils.
- Gently undulating plain under the weed-ruderal community on clearing on gray forest soils.
- Bottom of the balka under the restoration of the linden in the birch community on the soils of the ravine-balka complex.

The flat interfluve easily moistened forest landscape under coniferous-small-leaved forests on gray forest loamy soils. The lithogenic basis is represented by marls, clays and sands of the Cretaceous system with small areas of Neogene sands, overlain by eluvial-deluvial clays, loams and sandy loams of the Pleistocene; in floodplains of streams – alluvial deposits. The relief is complicated by balkas and valleys of small rivers and streams, on the sides of which the processes of landslide formation are manifested, as well as bowl-shaped depressions, occupied by swamps. The soil cover is represented by gray forest soils; in swamps – peat-bog soils. Vegetation is represented by pine forests, mixed forests and post-forest meadow communities, in swamps – pine-birch elfin woodlands.

Stows:
- Gently undulating plain under the communities of pine and birch on sod-podzolic soils.
- Mesotrophic bog under the pine-birch elfin woodlands on peat-marsh gley soils.
- Gently undulating plain under the pine communities on sod-podzolic soils.
- Gently undulating plain under the meadow on gray forest soils.

**Figure 1.** Landscape structure of the territory of the state nature sanctuary "Sursky Peaks".

The forest landscape of wet floodplains of small rivers and streams under black sandstones and willows on alluvial-turf soils is confined to the floodplains of small rivers and streams. The lithogenic basis is alluvial sandy loams and loams of Holocene age. The relief is complicated by levees and low ridges, riverbed cuts, deeps, oxbow lakes. Micro-lakes of biogenic origin are not uncommon at beaver dams. Soils are alluvial-turf gley.

**Stows:**
- Stream valley under the community of black sandstones on alluvial-turf soils.
- Floodplain of the stream under the community of the birch and horsetail on alluvial-turf soils.
In the course of the research, numerous cases of violations of the environmental regime – clearing – were noted. A network of forest roads is widely developed, which also reduces the nature protection function of the reserve (figure 1, table 1).

Table 1. Indicators of anthropogenic disturbance of landscapes of the territory of the state nature sanctuary "Sursky Peaks".

| Landscape                                                                 | Landscape area, km² | Area of clearings, km² | Percentage of disturbed territories, % |
|--------------------------------------------------------------------------|---------------------|------------------------|---------------------------------------|
| 1. The watershed easily moistened dune-bumpy forest landscape under pine forests on sod-podzolic soils | 38.346              | 6.04                   | 15.7                                  |
| 2. The sloping easily moistened forest landscape under coniferous-small-leaved forests on sod-podzolic soils | 46.073              | 3                      | 6.5                                   |
| 3. The flat interfluve easily moistened forest landscape under coniferous-small-leaved forests on gray forest loamy soils | 27.017              | 0.23                   | 0.85                                  |
| 4. The forest landscape of wet floodplains of small rivers and streams under black sandstones and willows on alluvial-turf soils | 3.95447             | 0.011                  | 0.278                                 |

4. Discussion
The territory of the sanctuary is characterized by a significant degree of anthropogenic transformation, intensive clearing is carried out in the central and southern parts, a network of earth roads is laid, which reduces the environmental value of protected areas, leads to a reduction in biodiversity [9] and contradicts the environmental regime of this protected area.

Clearing is widely carried out or was carried out until recently, the share of clearings and pine forest wastelands is 7% of the area of the sanctuary (figure 1, table 1), which is categorically unacceptable and contradicts the status and logic of creating a protected area.

The watershed easily moistened dune-bumpy forest landscape under pine forests on sod-podzolic soils and the sloping easily moistened forest landscape under coniferous-small-leaved forests on sod-podzolic soils suffered especially badly from clearing – firstly, because of the predominance of pine stands, very attractive for loggers, and secondly, because of the good patency of dry sandy roads on watersheds and slopes. The fact of a strong dependence of the degree of anthropogenic disturbances on the landscape structure of the researched territory is noted (figure 1, table 1).

The sanctuary, as an area with an important water protection and anti-erosion role, retains its significance. The landscapes of the reserve are the reference for the South Ulyanovsk watershed and the Predvolzh'e region. The wetlands, disturbed in the past, which are the habitat of a number of rare plant species for the Ulyanovsk region, are being restored and perform their environmental functions, as evidenced by the presence of a number of rare plant species at once (on the shores of Lake Svetloye).

5. Conclusion
Most of the territory of the sanctuary "Sursky Peaks" is characterized by high indicators of anthropogenic disturbance (numerous clearing, dense network of earth roads), which indicates a significant level of existing economic demand for the territory.

An additional factor that increases the rate of disturbance of natural complexes is the presence of objects with high tourist attraction [10-11] (primarily lake Svetloe); within these landscapes, control of the level of anthropogenic pressure is required.

At the same time, two landscapes on the territory of the sanctuary have a noticeably lower indicator of anthropogenic disturbance – this is explained by the much lower suitability of these two landscapes for clearing and more problematic conditions for laying and maintaining roads, necessary for the removal of forests.
Thus, the indicator of landscape preservation and the level of their involvement in economic activity has a pronounced landscape predetermination, which confirms the need to use a landscape approach in planning and implementing environmental protection activities in the sanctuary.

The main condition for the preservation of the landscapes of the sanctuary "Sursky Peaks" is the effective protection of forests that have high water conservation value and ensure the fullness of springs, rivers and lakes and the complete preservation of swamps and lakes as environment-forming reservoirs of clean fresh water.

To improve environmental work in the sanctuary "Surskie Vershy" it is necessary:

- To prevent clearing in protected areas and preserve large forests around rivers, lakes and swamps.
- To carry out all necessary fire-fighting measures in the required time to preserve forests and swamps from fires in problem areas.
- To prevent reclamation works that can harm lakes and swamps of protected areas.
- To explain to vacationers and tourists on the territory of the sanctuary the rules of conduct, for which to place full houses with the rules of conduct on the borders of the protected areas.

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