Landscape structure of the territory of the Kilemarsky section of the projected National Park Nizhegorodskoe Zavolzh'e (Nizhny Novgorod Region, Russia)

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Abstract. The article presents the results of landscape differentiation of the territory of the Kilemarsky section of the projected National Park Nizhegorodskoe Zavolzh'e, performed at the hierarchical level of landscape types. The territory of the Kilemarsky section of the projected national park lies in the Eurasian taiga (coniferous forest) botanico-geographical area, in the subzone of the southern taiga. According to the botanico-geographical zoning of the European part of Russia, its territory belongs to the Kama-Pechera-West Ural subprovincion of the Ural-West Siberian taiga province. The specifics of the national park's operating mode require functional zoning of the territory, taking into account the vulnerability of natural complexes, permissible recreational pressure and areas of propagation of rare plant and animal species, which determines the high demand for landscape zoning schemes, necessary for the effective organization of environmental and recreational activities. The article presents a scheme of landscape zoning of the territory of one of the five sections of the projected National Park Nizhegorodskoe Zavolzh'e – Kilemarsky. The work was carried out on the basis of field and desk researches, conducted in 2022. During the research seven landscapes were identified and briefly characterized.

1 Introduction

Nizhny Novgorod Region is a region, characterized by landscape diversity – it is located within three landscape zones – taiga, mixed coniferous-deciduous forests and forest-steppe. Such a high landscape diversity requires the adaptation of approaches to the organization of economic and environmental activities to local conditions. For the effective organization of nature protection in the Nizhny Novgorod region, a wide network of protected areas of different categories has been created – natural monuments, sanctuaries, one reserve and one natural park have been created. The work on the organization of the National Park

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Nizhegorodskoe Zavolzh'e is coming to an end, which will have a cluster structure – five of its sections lie in the landscape zones of the taiga, subtaiga and forest-steppe [1], which provides coverage of all natural zones of the Nizhny Novgorod region and makes the national park structurally and functionally representative.

However, the landscape approach [2, 3] when planning a national park should be implemented not only at the stage of planning the placement of national park sites in various natural zones of the region, but also when designing functional zones of each site – for the most effective organization of environmental and recreational functions of the national park. To do this, it is necessary to perform landscape mapping of the territory at the level of landscape types and to know the composition and features of the stows, typical for each landscape. However, due to the complexity of the task of large-scale landscape mapping, such maps are available only for individual territories [4]. The Kilemarsky section of the projected National Park Nizhegorodskoe Zavolzh'e has obvious scientific, environmental [5, 6] and recreational significance. In view of this, landscape researches were conducted on its territory in 2022, the results obtained during the research – a landscape map and a description of each landscape – can be used to develop a scheme for functional zoning of the Kilemarsky section and calculation of permissible recreational pressure.

2 Materials and methods

The purpose of the research: to develop a scheme of landscape differentiation of the territory of the Kilemarsky section of the projected National Park Nizhegorodskoe Zavolzh'e.

Object of research: the territory of the Kilemarsky section of the projected National Park Nizhegorodskoe Zavolzh'e.

Subject of research: landscape structure of the territory of the Kilemarsky section of the projected National Park Nizhegorodskoe Zavolzh'e.

The work was carried out based on the results of field and desk researches, conducted by the authors in 2022.

In the course of the work, the following research methods were applied: descriptive, cartographic, GIS analysis, analysis of literature and stock materials, statistical, expeditionary, remote researches, landscape zoning, comparative geographical.

In the course of the work, maps of pre-quaternary [7, 8] and quaternary [9, 10] deposits of 1:200000 scale, materials of the Atlas of Soils of Russia [11] and the soil map of the Nizhny Novgorod region [12], a map of landscape areas of the Nizhny Novgorod region [13], satellite images of the researched territory were used.

3 Results

The territory of the Kilemarsky section of the projected National Park Nizhegorodskoe Zavolzh'e is located in the north-east of the Nizhny Novgorod region, at the junction of Sharangsky and Voskresensky districts. The basis for its creation is the Kilemarsky Sanctuary. The area of the Kilemarsky section is 269 km^2.

The geological structure and relief of the territory of the Kilemarsky section of the projected national park in the XX century were researched by Z.K. Barashkova, O.E. Chumakov, B.I. Friedman, L.N. Pozdnyakov.

I.V. Zykov (1935), S.B. Kulvanovsky (1937, 1946, 1958), S.M. Agafonova (1974), V.I. Kolkutin (2006) and other researchers researched the climatic conditions and features of the Nizhny Novgorod region.

A systematic research of the hydrographic network of the Kilemarsky section of the projected national park was not carried out, the morphometric and hydrological

characteristics of the only Lake YUrongskoe were established by Nizhny Novgorod geographers [14].

The nature of the soil cover of the researched territory is reflected in the works of V.A. Romanov [12].

The great scientific significance of the broad-grass ramens, as plant groups, that help to understand the historical processes of the formation of the vegetation cover of the entire European part of Russia, The Nizhny Novgorod Geobotanical Expedition (1925-1928) showed, in which V.V. Alekhin [15], A.A. Uranov, S.S. Stankov [16], D.S. Averkiev, M.I. Nazarov, P.A. Smirnov, A.E. Zhadovsky, N.Ya. Katz and others worked. In their reports they pointed out the uniqueness of the broad-grass ramens of the Zavolzh'e region, noting their dual and relict nature. According to the results of the expedition, six island sections of these forests were found in the Zavolzh'e region. It was noted, that they were changed by man as a result of logging and clearing for arable land, because they occupy the richest soils. Over the years, that have passed since that time, these forests have undergone further reduction and to date only isolated sections of them have been preserved, not disturbed by logging. The areas of broad-grass ramens. The areas of broad-grass ramens, included in the Kilemarsky Sanctuary are the remains of the southernmost island of their propagation, identified by the Nizhny Novgorod geobotanical expedition, which is located along the middle course of the YUronga River.

At the end of the XX century, A.I. Shirokov researched the ecological features, the intra-cenotic structure and dynamics of linden fir-spruce forests in the conditions of the southern taiga of the lowland Zavolzh'e region [17].

N.Y. Kiseleva, S.V. Bakka were engaged in the research of the animal world and nature protection issues [18, 19, 20].

The position of the territory of the Kilemarsky section of the projected National Park Nizhegorodskoe Zavolzh'e in the system of natural zones and landscape areas of the Nizhny Novgorod region is reflected in the works of F.M. Bakanina [13].

The lithogenic basis is represented by pre-quaternary sediments of Permian age, overlain by the thickness of water-glacial deposits of the glacier retreat time (sands, loams, sandy loam) of the Don horizon.

Pre-quaternary deposits in the south of the Kilemarsky section of the projected Nizhny Novgorod Zavolzhye National Park are represented by sands, siltstones, clays of the Neogene system. Siltstones, clays, sandstones, and conglomerates of the lower Triassic system are common in the north.

In the west, in the central part and in the east of the Kilemarsky section, clays, siltstones, sandstones, conglomerates, marls of the upper Permian system are common. In the southeast there are clays, siltstones, sandstones, conglomerates, marls, limestones of the upper Permian system [7, 8].

Quaternary deposits of the eastern part of the Kilemarsky section are represented by eluvial-deluvial deposits (loams, sands).

Fluvioglacial deposits (sands, rarely loams) are represented in the northern, western and southern parts of the researched territory. Swamp sediments (peat) are dispersed in small areas. Alluvial deposits (sands, loams) are common on floodplains [9, 10].

The territory of the Kilemarsky section is located on the territory of the Zavetluzhskaya lowland. The surface decreases from the center to the periphery, reaching minimum levels in the southwest – at the water edge of the YUronga River.

The amplitude of the heights is 68 m (from 81 m at the water's edge of the YUronga River) to 149 m in the central part of the researched territory.

The climate is moderately continental with cold winters and moderately hot summers. Climatic conditions are typical for the northern and northeastern parts of the Nizhny

Novgorod region. The territory of the Kilemarsky section is located in the Vetluzhsky climatic region in the moderately humid agro-climatic region of the Zavolzh'e region [21].

The territory is drained by a multitude of small rivers and streams, radially diverging from the watershed in the central part of the Kilemarsky section, areas of swamps are often found on floodplains and even watershed slopes. The main rivers in the cluster are YUronga, Shushkan, Tyunga, Pishtan, Sharsha, Shkleya. The total area of the marshes is 14.72 km^2. The swampiness of the territory is 5.5%.

On the territory of the Kilemarsky section there is Lake YUrongskoe, where a rare species for the Nizhny Novgorod region grows – *Nymphoides peltata*. The lake has paleothermokarst origin [14], is a natural monument of regional significance [22].

On the territory of the Kilemarsky section, sod-podzolic, floodplain, peat-swamp soils are common. Due to the low average annual temperature and waterlogging, organic matter is not so much decomposed as washed away, the soils here are poorly fertile [12].

Sod-podzolic soils are common on well-drained elevated plains (plakors) under coniferous-deciduous forests. In the same relief depressions, especially in the valleys of large rivers, in conditions of close occurrence of groundwater, drainage deteriorates sharply. Periodic stagnation of precipitation moisture, on the one hand, and flooding by groundwater, on the other, lead to waterlogging. According to the mechanical composition, the soils are light loamy, sandy, medium loamy [11].

The territory of the Kilemarsky section lies in the Eurasian taiga (coniferous forest) botanico-geographical area, in the subzonal band of the southern taiga. According to the botanico-geographical zoning of the European part of Russia, its territory belongs to the Kama-Pechera-West Ural subprovincion of the Ural-West Siberian taiga province [23]. On its territory, the system of the largest fragments of intact southern taiga forests with oak forest elements – broad-grass ramens in the Nizhny Novgorod region has been preserved. This array of intact forest ecosystems is one of the largest in the southern taiga zone in Europe.

Among the high-age forests of the Kilemarsky section, the most common are fir-spruce linden nemoroseherb-fern and nemoroseherb-oxalis. In them the first tier of the stand is represented by European spruce, Siberian fir, birch and aspen, including giant aspen, which is of great scientific interest. The age of spruce and fir is 100-200 years. A number of rare plant species, growing on the borders of the habitats, both typical European oak forest (*Galeobdolon luteum, Lunaria rediviva*) and Siberian taiga (*Ligularia sibirica*, *Schizachne callosa*, etc.), have been noted. Researches, conducted in fir-spruce forests with oak elements on the territory of the Kilemarsky Sanctuary in the 1990s, proved their climax character. The sanctuary has become a model platform for researching the structure of indigenous southern taiga ecosystems, the patterns of their partial structure, spatial and temporal dynamics were established here for the first time [17].

According to the scheme of landscape zones proposed by A.G. Isachenko, the Kilemarsky section of the projected National Park Nizhegorodskoe Zavolzh'e lies in the taiga zone (subzone of the southern taiga) [1, 24] (Fig. 1).

Below is a map of the landscapes of the Kilemarsky section of the projected National Park Nizhegorodskoe Zavolzh'e, developed by the authors (Fig. 2) and a brief description of them is given.

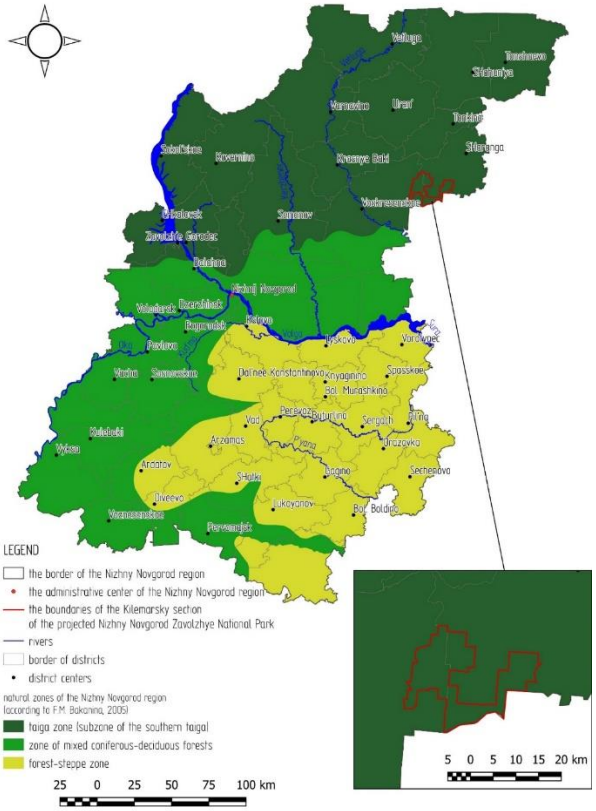

Fig. 1. The position of the territory of the Kilemarsky section of the projected National Park Nizhegorodskoe Zavolzh'e in the system of landscape zones of the Nizhny Novgorod region.

3.1 The alluvial landscape of floodplains of small rivers and streams under alders and willows on floodplain soils has an area of 7.4 km2

The lithogenic basis is alluvial loams, sandy loams and sands. The relief is complicated by riverbed shafts, hummocks, and barrels. In conditions of constant waterlogging, communities of willows, alders, and sedge meadows are formed within the landscape on floodplain soils, often gleizationed. Lowland swamps are often formed on the site of deeps. The area of marshes in the landscape is 0.001 km^2.

Typical stows:

• Ridge-hollow floodplain, complicated by man-made dredging and embankments under the communities of *Alnus incana, Ulmus laevis* and *Filipendula ulmaria* on alluvial-turf soils;

• Floodplain under the community of *Phalaroides arundinacea* on alluvial-turf soils;

• Floodplain of the stream under the community of *Betula pendula* and *Filipendula ulmaria* on alluvial-turf soils;

• Damp hillock floodplain under the community of *Alnus incana, Picea* × *fennica* nemorose-floodplaingrass on alluvial-turf gleizationed soils;

• Floodplain of the stream under the community of *Alnus incana* and *Filipendula ulmaria* on alluvial-turf soils.

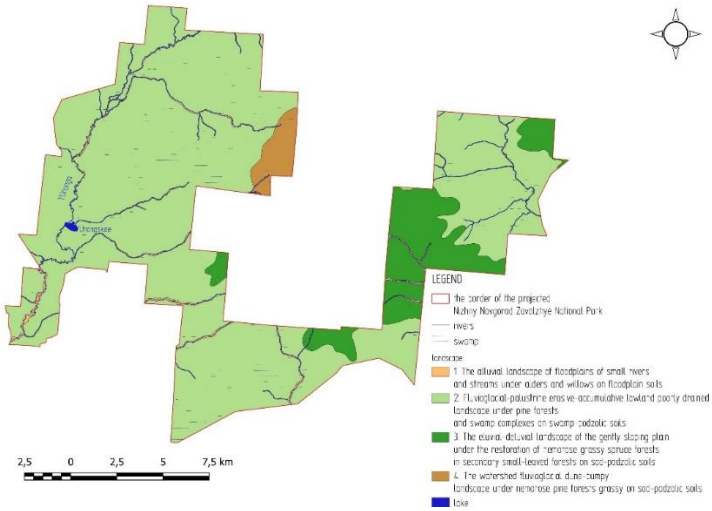

Fig. 1. The position of the territory of the Kilemarsky section of the projected National Park Nizhegorodskoe Zavolzh'e in the system of landscape zones of the Nizhny Novgorod region.

3.2 Fluvioglacial-palustrine erosive-accumulative lowland poorly drained landscape under pine forests and swamp complexes on swamp-podzolic soils the largest landscape within the researched area – has an area 23.9 km2

The lithogenic basis of this landscape was formed during the era of degradation of the maximum glaciation and is represented by fluvioglacial sands, on which younger palustrine series lie. High forest cover and weak slopes caused poor drainage of the territory and provoked the development of waterlogging. The relief is complicated by sandy ridges, deeply jutting into swamps and often complicated by dunes and interdune depressions. Lake YUrongskoe is located in this landscape. The soil cover is represented by peat-swamp soils; podzolic and sod-podzolic soils are formed on sandy ridges. The vegetation of the bogs is represented by complexes of oligotrophic, mesotrophic and eutrophic bogs, on sandy ridges heather pine forests and white moss pine forests are common. Forest cover: 95%. Swamp area: 10.5 km^2, waterlogged 4.7%. Due to slight slopes, the landscape area is poorly drained. There is a restoration of indigenous plant communities – spruce and fir forests, less often – pine forests on the site of small-leaved forests, that arose on the sites of long-standing logging.

Typical stows:

• Gently undulating plain under the restoration of spruce forest in the community of *Betula pendula, Populus tremula* and nemorose diverse grasses on sod-podzolic soils;

• Gently undulating plain under the community of *Betula pendula* and *Carex pilosa* on sod-podzolic soils;

• Gently undulating plain under the restoration of spruce forest in the community of *Betula pendula* and nemorose pine forest grasses on sod-podzolic soils;

• Gently undulating plain under the community of *Picea* × *fennica* and *Vaccinium myrtillus* on sod-podzolic soils;

• Gently undulating plain under the restoration of spruce forest in the community of *Betula pendula, Populus tremula* and nemorose pine forest grasses on sod-podzolic soils;

• Gently undulating plain under the community of *Picea* × *fennica* and *Abies sibirica* on peat-bog soils;

• Flat, damp plain under haircap-moss *(polytrichum)* spruce forest on peat-swamp soils;

• Flat-hummock plain under restoration community of *Picea* × *fennica, Euonymus verrucosus* and *Vaccinium vitis-idaea* on sod-podzolic soils;

• Gently undulating plain under the restoration of a spruce forest in a birch forest with the community of *Deschampsia cespitosa* and ferns on sod-podzolic soils;

• Flat-hummock plain under spruce-pine forest with the community of *Vaccinium myrtillus, Vaccinium vitis-idaea, Hylocomium, Dicranum, Rhutidiadelphus* on sod-podzolic gleizationed soils;

• Interdune depressions with a transitional bog under a pine forest with the community of *Vaccinium myrtillus, Vaccinium vitis-idaea, Eriophorum vaginatum* and *Sphagnum*;

• Gently undulating plain under the restoration of pine forest in a meadow with a community of various cereals;

• Ridge-dune plain under cowberry pine forest on sod-podzolic soils.

3.3 The eluvial-deluvial landscape of the gently sloping plain under the restoration of nemorose grassy spruce forests in secondary small-leaved forests on sod-podzolic soils has an area of 31.4 km2

Forest cover: 98%. Swamp area: 0.316 km^2. The landscape has a heavier soil texture compared to other landscapes of the Kilemarsky s section – light loams are common here, which led to greater soil fertility and widespread spread along with coniferous species of broad-leaved trees – *Ulmus laevis*, *Acer platanoides, Tilia cordata* and *Quercus robur*. Nemorose species are widespread in the herbage.

Typical stows:

• Gently undulating plain under spruce-pine forest (with an admixture of *Ulmus laevis*) nemorose grassy on sod-podzolic soils;

• Gently undulating plain under the community of *Picea* × *fennica* and *Ulmus laevis* nemorose grassy on sod-podzolic soils;

• Gently undulating plain under the restoration of a spruce forest in an aspen forest nemorose grassy on sod-podzolic soils;

• Gently undulating plain under the community of *Betula pendula* and *Filipendula ulmaria* on sod-podzolic soils;

• Flat-hummock plain under the aspen-spruce forest nemorose grassy on sod-podzolic soils.

3.4 The watershed fluvioglacial dune-bumpy landscape under nemorose pine forests grassy on sod-podzolic soils has an area of 6.3 km2

The lithogenic basis of the landscape is eluvial-deluvial deposits (loams, sands). Being located on the watershed, the surface has slopes, due to which the landscape is drained, swamps are developed locally and are confined to epilimnas – post-lake formations. The sources of several small rivers are located within this landscape. Pine forests have formed on fresh sandy and sandy loam sod-podzolic soils: blueberry, lingonberry, lily of the valley, green moss and others. Forest cover: 95%. Swamp area: 0.263 km^2, waterlogged 4.2%.

Typical stows:

• Flat-hummocky plain under the pine forest with the community of *Pteridium aquilinum, Vaccinium myrtillus, Vaccinium vitis-idaea, Hylocomium, Dicranum, Rhutidiadelphus* on sod-podzolic soils;

• Gently undulating plain under the restoration of spruce forest in blueberry birch forest on sod-podzolic soils;

• Gently undulating plain under the restoration of spruce forest in birch forest on sod-podzolic soils;

• Gently undulating plain under the restoration of spruce forest in birch forest nemorose grassy.

4 Conclusion

The Kilemarsky section, being a place of growth of relict broad-grass ramen, certainly deserves to be included in the protected area, however, the national park has, in addition to environmental protection, also a recreational function, which determines the need to allocate recreational zones, that determines carrying out functional zoning of the territory. This task is most effectively solved on the basis of landscape maps. This paper presents the results of landscape researches in the form of a landscape map and a brief description of the selected landscapes. The results of the research can be used in the design of functional zones of the Kilemarsky section of the National Park.

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