Landscape differentiation of the territory of the Voskresensky district of the Nizhny Novgorod region

A E Astashin1,2, M M Badin1, V A Ufilina1, A V Samoylov1,3 and M N Pashkin1

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

3 E-mail: guardangel93@hotmail.com

Abstract. The article presents the results of landscape differentiation of the territory of the Voskresensky district of the Nizhny Novgorod region. The territory of the Voskresensky district, which has high indicators of tourist and recreational potential, needs to be considered from the perspective of landscape zoning. The research established boundaries and described 11 landscapes, as well as a landscape map of the territory of the Voskresensky district.

1. Introduction
The need to take into account the landscape characteristics of the territory during spatial planning and the organization of economic activities is obvious. The landscape, which is a focus in which specific morpholithogenic, climatic, hydrological, soil and biotic characteristics of the territory intersect, is the basis on which the economy develops, the framework of settlement is formed, the culture and mentality of the local population are crystallized. Ignoring the landscape specifics of the territory is incompatible with efficient management [1].

In order to identify the landscape structure in the territory of the Voskresensky district in 2019-2020 field researches were carried out, during which descriptions of typical tracts were performed, natural combinations of which together form landscapes. Based on the analysis of thematic maps, remote Earth sensing data and field researches, a landscape zoning scheme of the territory of the Voskresensky district of the Nizhny Novgorod region was compiled. The synthesis and spatial analysis of the data was carried out using a multifunctional geographic information system QuantumGIS. During the landscape zoning of the territory of the Voskresensky district, we relied on the scheme of landscape zoning of the Nizhny Novgorod region by F.M. Bakanin and co-authors, carried out in 2003 at the level of landscape districts [2].

2. Results and discussion
The territory of the Voskresensky district is located in the east of the Nizhny Novgorod region in its left-side part in the Vetluga river basin. The area of the Voskresensky district is 3,554 km². The northeastern part of the Voskresensky district lies within the Zavolzhskaya rudimentary reduced upland; the northern and central part is on the territory of the Volga-Vetluzhsky lowland. This surface is a hollow, shallow-
clumped tuberous-hryvnia surface of the zander plains and Volga post-glacial floodplain terraces with swamps and lakes. Numerous longitudinal parabolic dunes of aeolian origin oriented to the northeast are inherent. These surfaces alternate in stripes with vast flat spaces of hummockish marshes. The southern part of the district is located on the territory of the Semenovsky plateau. This is a low-lying plain created on the buried surface of lobe alluvial deposits, covered by glacial deposits. The surface of the plateau includes a high lobe Early Pleistocene terrace. The surfaces of the terraces are eroded and blocked by glacial deposits, including the remains of moraines, so glacial morphosculture dominates within the Semenovsky plateau. On the surface of the plateau, hilly and tuberous-hryvnia relief forms are developed [3]. Absolute heights range from 67 m - the Vetluga cliff to 131 m in the northwest and northeast of the region.

Sedimentary cover the territory of the Voskresensky district is represented by indigenous sediments of Permian system in the Russian stratigraphic scheme (clays, sands, sandstones, siltstones), the Triassic system (clays, siltstones, sands), Jurassic system (clays, siltstones, sands) and Paleogene systems (clays, siltstones, sands) [4]. Quaternary deposits on the territory of the Voskresensky district are mainly represented by sands, clays, and loams [5].

According to climatic characteristics, the territory of the Voskresensky district belongs to the moderately humid agro-climatic region of the Volga region [6]. The average annual precipitation in the Voskresensky district is 583 mm [7]. The average monthly wind speed in winter is higher than in the warm period and is 3.5-4.5 m/s [8]. On the territory of the Voskresensky district, westerly and South-westerly winds prevail. The average temperature in January is -13.4°C, in July +18.6°C.

The annual flow modulus of rivers ranges from 5 l/s/km² in the South of the district to 7 l/s/km² in the North [9]. The total length of watercourses is 887.7 km, including the Vetluga river – 91.7 km; the density of the river network of the Voskresensky district is 0.24 km/km².

Most of the district is located in the Vetluzhsky soil-geographical district. Voskresensky district is characterized by 4 types of soil: sod (a section of the southern taiga), sod-podzolic (under mixed forests), swamp-podzolic and swampy, podzolic floodplain-alluvial in river valleys [6]. Due to the low average annual temperature and waterlogged organic matter in the soil is not so much decomposed as washed out. Therefore, the soil here is infertile. The mechanical composition of the soil is sandy and sandy loam.

Figure 1. Landscape structure of the territory of the Voskresensky district.
The total area of forests on the territory of the Voskresensky district is 2676 km², with 75.3% forest cover. Forests cover most of the area, and forest cover is noticeably reduced only near the river, where a large part of the population of the area, and its economic activity was much more pronounced.

The article presents the results of research, conducted in the period 2019-2020. On the territory of the Voskresensky district, the authors identified 11 landscapes based on structural and genetic classification (table 1, figure 1) located within the South taiga and Subtaiga subzones, Unzhensko-Vetluzhsky landscape province, in 5 landscape districts: the Vetluzhsky, Vetluzhsko-Ustansky, Verhne-Kerzheneckij, Chkalovsko-Semenovskij, Nizhne-Kerzheneckij.

From the 11 selected landscapes, 9 (landscapes 1-5, 8-11 in table 1) are located within landscape areas, and 2 (landscapes 6 and 7 in table 1) are intrasonal and are represented in several landscape districts at once [2].

**Table 1. Landscape structure of the territory of the Voskresensky district (according to F. M. Bakanina with additions by the authors).**

| Zone: Forest | Subzone: South taiga sub-Taiga | Province: Unzhensko-Vetluzhskaya | Landscape district |
|--------------|---------------------------------|----------------------------------|--------------------|
| I. Privetluzhsky | II. Vetluzhsko-Ustanskiy | III. Verhne-Kerzheneckij | IV. Chkalovsko-Semenovskij | V. Nizhne-Kerzheneckij |
| Landscapes | Landscapes | Landscapes | Landscapes | Landscapes |
| Slope erosion-denudation bog fresh agricultural landscape under agrocenoses and opolje on sod-podzolic loamy soils | 1. Agrolandscape of a morainic gently undulating plain under opolje on sod-podzolic loam soils | 3. Forest landscape of fluvioglacial dune-bumpy inhomogeneously drained plain under pine trees on sod-podzolic sandy loam soils | 5. Forest landscape of a fluvioglacial dune-bumpy plain on the third above-floodplain terrace, complicated by swamps on epi-lims under pine forests on sod-podzolic sandy loam soils | 9. Slope erosion-denudation bog fresh agricultural landscape under agrocenoses and opolje on sod-podzolic loamy soils |
| Near-valley forest landscape of a gently sloping moraine plain under spruce-pine forests on sod-podzolic sandy loam soils | 2. Near-valley forest landscape of a gently sloping moraine plain under spruce-pine forests on sod-podzolic sandy loam soils | 4. Forest landscape of fluvioglacial dune-bumpy fresh plain under secondary coniferous-small-leaved forests on sod-podzolic sandy loam soils | 6. Watershed moraine-hilly hilly fresh forest landscape of a morainic gently sloping plain under forest crops and secondary coniferous-small-leaved forests on sod-podzolic loam soils |
| Forest landscape of fluvioglacial dune-bumpy fresh plain under secondary coniferous-small-leaved forests on sod-podzolic sandy loam soils | 7. Watershed moraine-hilly fresh forest landscape of a morainic gently sloping plain under forest crops and secondary coniferous-small-leaved forests on sod-podzolic loam soils |
| Watershed moraine-hilly fresh forest landscape of a morainic gently sloping plain under forest crops and secondary coniferous-small-leaved forests on sod-podzolic loam soils | 10. Watershed moraine-hilly fresh forest landscape of a morainic gently sloping plain under forest crops and secondary coniferous-small-leaved forests on sod-podzolic loam soils |
| Fluvioglacial-palustrine forest landscape of a gently sloping swampy plain under pine trees and swamp complexes on peat-marsh soils | 11. Fluvioglacial-palustrine forest landscape of a gently sloping swampy plain under pine trees and swamp complexes on peat-marsh soils |
2.1. Privetluzhsky landscape district (I in the table 1)

2.1.1. Slope erosion-denudation bog fresh agricultural landscape under agrogenosis and opolje on sod-podzolic loamy soils (landscape 9 in the table 1). Landscape is located in the Central part of the Voskresensky district. The landscape stretches from Northwest to Southeast along the river Vetluga. The area is 285.9 km². Pre-Quaternary deposits are represented by deposits of the Triassic system – clays with layers of siltstones, sands and conglomerates; the Permian system (Tatar series, Severodvinsk and Vyatka stage) – marls and clays with layers of siltstones, limestones and dolomites [4]. Quaternary deposits are represented by submerged fluvio-glacial deposits of the Dnieper horizon – sands with rare layers of loam, as well as overlying fluvio-glacial deposits of the Dnieper horizon – sands, less often loams; slightly represented are marsh deluvial deposits of the modern Department (peat, loam), alluvial, eluvial-deluvial deposits (loam, sand), glacial deposits of the Dnieper horizon (loam with pebbles and boulders) [5]. The terrain is generally flat, but near the river Vetluga there are strong differences in altitude (from 120 m to 70 m). The length of permanent watercourses is 11.7 km. The density of the river network of the landscape is 0.04 km/km². The territory of the landscape is covered with sod-podzolic loamy soils, near the river Vetluga observed alluvial-turf soils. 94.3 km² is forested (32.9% of the total area). The territory is highly transformed, it is an agricultural landscape.

2.2. Vetluzhskio-Ustanskiy landscape district (II in the table 1)

2.2.1. Agrolandscape of a morainic gently undulating plain under opolje on sod-podzolic loam soils (landscape 1 in the table 1). Landscape is located in the Northern part of the Voskresensky district; the area is 250.6 km². Pre-Quaternary deposits are represented by clays with layers of siltstones, sands and conglomerates of the Triassic system; Jurassic system – clays with layers of siltstones and sands; Permian system – marls and clays with layers of siltstones, limestones and dolomites [4]. Quaternary deposits are mainly represented by deposits of the middle section – alluvial deposits that make up the third above-floodplain terrace (sands with layers of loam), as well as deposits of the upper section of the mologosheksinsky-ostashkovsky horizons – alluvial deposits of the first above-floodplain terrace in the form of loams, siltstones, sands at the base with gravel. The Northern and Eastern parts of the landscape are represented by overlying fluvio-glacial deposits of the Dnieper horizon (sand, less often loam). To a lesser extent, Quaternary deposits are represented by deposits of the modern department – alluvial deposits (loams, sands) [5]. The territory of the landscape is a morainic gently undulating plain, the terrain is flat, elevated, with elevation differences from 80 to 110 m. The length of permanent watercourses is 4.5 km. The density of the river network of the landscape is 0.01 km/km². The territory of the landscape is covered mainly with sod-podzolic sandy soils, on floodplains of rivers alluvial-sod soils. 136.3 km² is covered by forest (55.5% forested).

2.2.2. Near-valley forest landscape of a gently sloping moraine plain under spruce-pine forests on sod-podzolic sandy loam soils (landscape 2 in the table 1). Landscape is located in the Northern part of the Voskresensky district; the area is 162.2 km². Pre-Quaternary deposits are represented by clays with layers of siltstones, sands and conglomerates of the Triassic system and clays with layers of siltstones and sands of the Jurassic system [4]. Quaternary sediments are mainly represented by deposits of the middle Department – overlying fluvio-glacial deposits of the Dnieper horizon (sands, less often loams), as well as submerged fluvio-glacial deposits of the Dnieper horizon (sands with rare layers of loam), glacial deposits of the Dnieper horizon (loams with pebbles and boulders), eluvio-deluvial deposits.
(loams, sands). To a lesser extent, Quaternary deposits are represented by deposits of the modern department – alluvial deposits (loams, Sands) [5]. The territory of the landscape is a gently sloping moraine plain, relief with a height difference from 90 to 140 m. There are no permanent watercourses on the territory of the landscape. The territory of the landscape is covered mainly with sod-podzolic sandy loam soils. 149.7 km² is forested (92.2% forested).

2.2.3. Forest landscape of fluvioglacial dune-bumpy inhomogeneously drained plain under pine trees on sod-podzolic sandy loam soils (landscape 3 in the table 1). Landscape is located in the North-Eastern part of the Voskresensky district; the area is 208.9 km². Pre-Quaternary deposits are represented by clays with layers of siltstones, sands and conglomerates of the Triassic system; clays with layers of siltstones and sands of the Jurassic system [4]. Quaternary deposits are mainly represented by deposits of the middle section-overlying fluvioglacial deposits of the Dnieper horizon (sands, less often loams), as well as submerged fluvioglacial deposits of the Dnieper horizon (sands with rare layers of loam). Marsh deposits of the modern Department (peat, loam) are distributed locally on the territory of the landscape [5]. The territory of the landscape is a dune-bumpy inhomogeneously drained plain, the terrain is flat, elevated, with a height difference from 100 to 150. The length of permanent watercourses is 5.8 km. The density of the river network of the landscape is 0.02 km/km². The territory of the landscape is covered mainly with sod-podzolic sandy loam soils. 193.1 km² is covered by forest (92.4% forested).

2.2.4. Forest landscape of fluvioglacial dune-bumpy fresh plain under secondary coniferous-small-leaved forests on sod-podzolic sandy loam soils (landscape 4 in the table 1). Landscape is located in the North-East and North-West of the territory of the Voskresensky district; the area is 523.6 km². Pre-Quaternary deposits are represented by clays with layers of siltstones, sands and conglomerates of the Triassic system, clays with layers of siltstones and sands of the Jurassic system, clays and siltstones replaced by sands and sandstones with layers of conglomerates of the Permian system [4]. Quaternary deposits are mainly represented by deposits of the middle section-overlying fluvioglacial deposits of the Dnieper horizon (sands, less often loams), as well as submerged fluvioglacial deposits of the Dnieper horizon (sands with rare layers of loam). Locally, alluvial and marsh deposits of the modern Department (peat, loam) are distributed throughout the landscape [5]. The landscape area is a dune-bumpy fresh plain, with a height difference of 80 to 150 m. The length of permanent watercourses is 7.9 km. The density of the river network of the landscape is 0.01 km/km². The territory of the landscape is covered with sod-podzolic sandy loam soils. 502.4 km² is covered with forest (95.9% forested).

2.2.5. Forest landscape of a fluvioglacial dune-bumpy plain on the third above-floodplain terrace, complicated by swamps on epilimns under pine forests on sod-podzolic sandy loam soils (landscape 5 in the table 1). Landscape is located in the East of the Voskresensky district; the area is 234.3 km². Pre-Quaternary deposits are represented by deposits of the Permian system (Tatar series, Severodvinsk and Vyatka stage) – marls and clays with layers of siltstones, limestones and Dolomites [4]. Quaternary sediments are mainly represented by deposits of the middle Department – alluvial deposits that make up the third above-floodplain terrace (sands with layers of loam), as well as overlying fluvioglacial deposits of the Dnieper horizon (Sands, less often loams) and deposits of the moloshkerninsky-ostashkovsky horizons – alluvial deposits (sands, at the base with gravel, loams, siltstones). Locally, alluvial and marsh deposits of the modern Department (peat, loam) are distributed throughout the landscape [5]. The territory of the landscape is a fluvioglacial dune-hummocky plain on the third above-floodplain terrace, relief with an amplification of heights from 70 m in the South to 110 m in the North. The length of permanent watercourses is 12.7 km. The density of the river network of the landscape is 0.05 km/km². The territory of the landscape is covered with sod-podzolic sandy loam soils. 200.3 km² is covered by forest (85.4% forested).
2.3. Verhne-Kerzheneckij landscape district (III in the table 1)

2.3.1. Watershed morainic hollow hilly fresh agrolandscape under agrocenoses, forest crops and secondary coniferous-small-leaved forests on podzolic loam soils (landscape 8 in the table 1). Landscape is located in the West of the Voskresensky district; the area is 155.3 km². The pre-Quaternary deposits are sediments of the Paleogene system Oligocene (sand with interlayers of clays and are litas), sediments of the Triassic system (clays with interlayers of aleurolites, sands and conglomerates), the sediments of Permian system (clays and siltstones, and alternate by sands and sand-kami with interlayers of conglomerates) [4]. Quaternary deposits are represented by deposits of the middle Department: glacial deposits of the Dnieper horizon (loams with pebbles and boulders), submerged fluvioglacial deposits of the Dnieper horizon (sands with rare layers of loam), overlain fluvioglacial deposits of the Dnieper horizon (sands, less often loams). Locally, alluvial (loam, sand) and marsh deposits of the modern Department (peat, loam) are distributed over the territory of the landscape [5]. The territory of the landscape consists of a morainic low-hilly plain, dissected by the valley of the river Lunda, terrain with a height difference from 110 to 150 m. There are no permanent watercourses on the territory of the landscape. The territory of the landscape is covered with podzolic loam soils. 73.8 km² is covered with forest (47.5% forested).

2.4. Chkalovsko-Semenovskij landscape district (IV in the table 1)

2.4.1. Watershed moraine hilly fresh forest landscape under forest crops and secondary coniferous-small-leaved forests on podzolic loam soils (landscape 10 in the table 1). Landscape is located in the southern part of the territory of the Voskresensky district; the area is 844.5 km². The landscape is the largest by area in the Voskresensky district. The pre-Quaternary deposits are sediments of the Paleogene system Oligocene (sands with interlayers of clays and siltstones), sediments of the Triassic system (clays with interlayers of aleurolites, Sands and conglomerates), the sediments of Permian system (clays and siltstones alternate Sands and sandstones with interlayers of conglomerates), as well as deposits of the Jurassic system (clays with interlayers siltstones and Sands) [4]. Quaternary deposits are represented by deposits of the middle Department: glacial deposits of the Dnieper horizon (loams with pebbles and boulders), submerged fluvioglacial deposits of the Dnieper horizon (sands with rare layers of loam), overlain fluvioglacial deposits of the Dnieper horizon (Sands, less often loams). Locally, alluvial (loam, sand) and marsh deposits of the modern Department (peat, loam), alluvial deposits of the mikulinsky-kalininskoye and mologoshkedsninsky-ostashkovskoye horizons (sand, at the base with gravel, pebbles, loam, siltstone) are distributed across the landscape [5]. The territory of the landscape is a watershred morainic hilly plain, dissected by the valley of the Lunda river; the height range is from 90 m to 150 m. The territory of the landscape is covered with podzolic loam soils. 643.9 km² is covered with forest (76.2% forested).

2.5. Nizhne-Kerzheneckij landscape district (V in the table 1)

2.5.1. Fluvioglacial-palustrine forest landscape of a gently sloping swampy plain under pine trees and swamp complexes on peat-marsh soils (landscape 11 in the table 1). Landscape is located in the South-Western part of the Voskresensky district; the area is 384.5 km². Pre-Quaternary deposits are represented by deposits of the Permian system (clays and siltstones, replaced by sands and sandstones with conglomerate layers), as well as insignificant deposits of the Paleogene system, Oligocene (sands with clay and siltstone layers) [4]. Quaternary deposits are represented by deposits of the middle Department: overlying fluvioglacial deposits of the Dnieper horizon (sand, less often loam). Locally, alluvial (loam, sand) and marsh deposits of the modern Department (peat, loam) are distributed over the territory of the landscape [5]. The territory of the landscape is a gently sloping swampy plain; relief with an amplitude of heights from 100 m to 130 m. There are no permanent watercourses. The territory of the landscape is covered with podzolic and peat-swamp soils. 320.1 km² is covered by forest (83.3% forested).
2.6. Intrazonal landscapes

2.6.1. Forest landscape of wet valleys of small rivers under alder trees on alluvial-turf soils (landscape 6 in the table 1). Landscape is located throughout the territory of the Voskresensky district along the rivers; the area is 310.7 km². Pre-Quaternary sediments, due to the intrasonality of the landscape, are diverse [4], Quaternary sediments are represented by alluvial (loam, sand) and marsh deposits of the modern Department (peat, loam) [5]. The landscape contains valleys of small rivers, the height difference from 80 to 140 m. The length of permanent watercourses is 755.6 km. The density of the river network of the landscape is 2.44 km/km². Alluvial-turf soils are ubiquitous.

279.2 km² is covered by forest (89.8% forested).

2.6.2. Alluvial bumpy-maned forest landscape complicated by meander lakes of floodplains of middle rivers under willows and alders on alluvial-turf soils (landscape 7 in the table 1). Landscape is located in the Central part of the Voskresensky district along the Vetluga; the area is 209.3 km². Pre-vertical deposits are represented by deposits of the Permian system (Tatar series, Severodvinsk and Vyatka stage) – marls and clays with layers of siltstones, limestones and Dolomites [5]. Quaternary deposits are mainly represented by alluvial deposits of the modern Department (loams and sands). Locally on-site distributed landscape modern swamp deposits division (peat or loam) and deposits moloshekskinskoy-ostashkovsky horizon of alluvial deposits (sand, base gravel, loam, siltstone) [5]. The territory of the landscape is a bumpy-maned plain, the terrain is flat with a height difference from 70 to 90 m. The length of permanent watercourses is 89.5 km. The density of the river network is 0.42 km/km². Alluvial-turf soils are ubiquitous. 83.3 km² is covered by forest (39.7% forested).

3. Conclusion

Inventory and the most accurate and complete assessment of available natural conditions and resources, spatial ordering and system accounting of natural conditions achieved by landscape zoning are the basis for effective territory management.

As a result of the research, the following results were obtained:

• a modern physical and geographical description of the territory of the Voskresensky district was performed;
• the scheme of landscape zoning of the territory of the Voskresensky district has been developed;
• using GIS, calculations of landscape areas and some of their characteristics (forest cover, river network density, height amplitude) were performed.

The results of the study can be used as a basis for conducting sectoral and comprehensive assessments of the territory, in the management and planning of development of the territory of the Resurrection district.

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