Landscape differentiation of the territory of the Knyagininsky district of the Nizhny Novgorod region (Russia)

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Abstract. The territory of the Knyagininsky district of the Nizhny Novgorod region, located in the north of the forest-steppe zone, is characterized, on the one hand, by high biological diversity characteristic, which typical for ecotones, on the other hand, by a high degree of anthropogenic transformation of landscapes. Both of these circumstances require a systematic – landscape – approach both to the organization of environmental management and to the planning and implementation of measures, providing environmental protection. However, to date, the scheme of landscape differentiation of the territory of the Knyagininsky district at the hierarchical level of landscapes required for making rational economic decisions, has not been developed. The article presents the results of landscape zoning of the territory of the Knyagininsky district of the Nizhny Novgorod region, performed on the basis of field researches, analysis of maps, literature sources and remote sensing data.

1. Introduction
Knyagininsky district is one of the main agricultural areas of the Nizhny Novgorod region, its territory is strongly transformed by economic activity. On the one hand, this greatly influenced the formation of the modern landscape structure of the district. On the other hand, the economic development of this territory itself was directly influenced by landscape conditions and, firstly, had a character, determined by landscape features, and secondly, inherited the spatial boundaries of landscapes. Thus, for the sustainable management of the territory necessary accounting qualitative characteristics and spatial structure of landscapes, but to date the scheme of landscape differentiation at hierarchical level of landscape developed only for certain territories in Nizhny Novgorod region [1]. In addition, the landscape, being a system structure, includes many components of living and inanimate nature, determining their composition and functioning, so the possession of information about the landscape structure of the territory is necessary for a systematic understanding of the situation by subject matter experts – pedologists [2-3], geomorphologists [4], botanists [5-6], ecologists [7-10], etc.

2. Materials and methods
Aim: to develop a scheme of landscape differentiation of the territory of Knyagininsky district at the hierarchical level of landscapes.

Object of research: territory of Knyagininsky district of the Nizhny Novgorod region.
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Source materials of the research: the results of field research, data from remote sensing of the Earth, thematic maps, literary sources.

Research methods: expedition, mapping, geoinformation, mathematical, analysis of the literature. At the pre-field stage, using the data of remote sensing of the Earth, thematic maps and literature sources, through the coupled analysis of spatial data using GIS QGIS 3.16.2, we outlined preliminary boundaries of landscapes and planned key points for conducting field descriptions. During the field stage, complex descriptions were made at 59 key points, which made it possible to clarify the landscape features of the territory and the boundaries of the landscapes. At the final cameral stage, a map of the landscapes of the Knyagininsky district was drawn (figure 1), descriptions of each landscape were given and a list of typical stows for each landscape was given.

3. Results
Knyagininsky district is located in the northern part of the forest-steppe zone in the north of the Privolzhskaya upland within the Oka-Volga right-bank area in the south-east of the central part of the Nizhny Novgorod region. The area of the research area is 769 km².

Lithogenic basis in most parts of the territory represented by sediments of the Tatar stage of Permian (conglomerates, sandstones, clays, marls, limestones, aleurolite and aleurite); in the central part, south-west and eastern outskirts spread Jurassic sediments (clay, marls, sands, sandstones, conglomerates phosphorite, shale fuel, aleurite and limestone); in the south-eastern part of the district are represented undifferentiated sediments of the Neogene system (sands, clays, aleurite, and gravel). Quaternary deposits on the territory of the Knyagininsky district are represented almost everywhere by loams, clays and sands.

The research area is a wavy (erosive-accumulative) plain, divided by a highly developed valley and ravine-balka network (1-1.5 km²).

The climate is temperate continental with relatively cold winters and warm summers. The average temperature in January is -10 °C, in July +23 °C; the annual precipitation is 582 mm.

7 rivers with a total length of 130 km flow through the territory of Knyagininsky district, the largest rivers are the Imza and Urga.

The soils are mainly gray forest loamy, mostly cultivated.

The total area of forests is 19.5 thousand hectares, forest cover is 25 %. Native forest vegetation – oak forests – is replaced by linden, birch, aspen, but more often destroyed. Previously forested areas are now occupied by crops or fallow lands. Preserved forests are scattered in small areas on the slopes of ravines and balkas. Unsuitable for plowing slopes have preserved the last sections of meadow steppes.

According to the results of field researches, conducted in the spring of 2020, landscape zoning was performed for the Knyagininsky district for the first time. In the process of landscape differentiation, we took into account all the components of the landscape and the type of nature management, which has an integral reflection in the indicator of forest cover. Landscapes with less than 25% forest cover are called agrolandscapes; 25-50% forest cover is called agroforestlandscapes. Three types of landscapes were identified: 1) flat interfluve moraine agricultural landscape under cultural vegetation and secondary forests on dark gray forest loamy soils; 2) slope erosion-denudation agroforest landscape under secondary small-leaved and broad-leaved forests, fallow and crop communities on gray forest heavily washed loamy soils; 3) wet agricultural landscape of small river floodplains under alder thickets, willow and sedge meadows on alluvial-sod soils (figure 1).

4. Discussion
Flat interfluve moraine agricultural landscape under cultural vegetation and secondary forests on dark gray forest loamy soils. The largest landscape, has an area of 432 km² (56% of the research area). The morpholithogenic basis is represented by flat watersheds and watershed slopes, underlain by moraine
loams, on which leached chernozems and dark gray forest soils were formed. On the territory of this landscape, the most economically valuable land is located – more than 80% of the farmland of the research territory is concentrated here. Due to the high demand for fertile soils, weakly inclined well-drained surfaces in agriculture, original vegetation – broad-leaved forest and steppe plant communities – are severely disturbed. The forest cover of 16%.

**Figure 1.** Map of landscape differentiation of the territory of the Knyagininsky district of the Nizhny Novgorod region

Typical for this landscape stows are:

- Flat interfluve under the cultural ruderal-segetal vegetation on gray forest loamy soils;
- Flat interfluve under the ruderal-gramineous meadow on gray forest loamy soils;
- Watershed slope under a birch tree of various grasses and gramineous on gray forest loamy soils;
- Watershed slope under a pine crop with a mixed grass-gramineous ground cover on gray forest loamy soils;
- Flat interfluve under aspen hazel sedge on gray forest loamy soils.

Slope erosion-denudation agroforest landscape under secondary small-leaved and broad-leaved forests, fallow and crop communities on gray forest heavily washed loamy soils. The area is 277 km² (36% of the research area). The morpholithogenic basis is represented by the slopes of river valleys (slopes of 3-8% dominate), bedded by moraine loams. Ravine-balka network is developed. The landscape is well drained. Gray forest loamy washed-out soils dominate; numerous shallow-contour areas of ravine-balka complex soils are present. Due to the active development of linear erosion,
relatively well preserved woody vegetation (including broad-leaved forests), confined to ravines, balkas and unsuitable for plowing slopes. The forest cover is 44%.

Typical for this landscape stows are:

- Confined to valley slope under the goat willow with mixed grass and gramineous ground cover on gray forest medium loamy soils;
- Confined to valley slope under linden sedge broad-grass on gray forest loamy soils;
- Confined to valley slope, complicated by gullies, under the cultural ruderal-segetal vegetation on gray forest loamy heavily washed soils;
- Gully under the maple tree sedge broad-grass on the soils of the ravine-balka complex;
- Gully under the gramineous-ruderal meadow on gray forest loamy soils;
- Slope of the small river valley, complicated by gullies, under a meadow of various grasses and gramineous on gray forest loamy heavily washed soils;
- Slope of the small river valley, complicated by gullies, under the young growth of pine on gray forest loamy heavily washed soils;
- Slope of the river valley, richly cut by ravines and balkas, under the culture of pine with sparse ground cover on gray forest loamy soils;
- Ravine under a meadow of mixed grasses on the soils of a ravine-balka complex;
- Ravine under the aspen goutweed on soils of a ravine-balka complex;
- Balka, complicated by gullies, under a birch tree gramineous-broad-grass on the soils of a ravine-balka complex;
- Balka with a secondary erosion cut-in under a ruderal-gramineous meadow on the soils of a ravine-balka complex;
- Slope of the stream valley under aspen birch hazel broad-grass on gray forest loamy soils;
- Root slope of the valley of the small river, complicated by landslide terraces, under a meadow of mixed grasses with spots of willow and rose on gray forest soils strongly washed.

Wet agricultural landscape of small river floodplains under alder thickets, willow and sedge meadows on alluvial-sod soils. Area: 60 km² (8% of the research area). The morpholithogenic basis is represented by floodplains of small rivers on alluvial loams, sandy loams and sands. The landscape is often wet or swampy. In the soil cover – alluvial-sod, often gley soils. Vegetation is represented by meadows and small-leaved and broad-leaved forests; in depressions of the floodplains alder thickets are frequent. Floodplain meadows are good hayfields. The forest cover is 18%.

Typical for this landscape stows are:

- Floodplain of the small river under the alder thicket wild hop meadowsweet on alluvial-sod soils;
- Floodplain of the small river, complicated by the reservoir, under the alder thicket willow-sedge on alluvial-sod soils;
- Floodplain of the small river under the alder thicket sedge on alluvial-sod soils;
- Floodplain of a small river under alder thicket with a community of ruderal plants on alluvial-sod soils;
- Wet low floodplain of the small river under the southern reed community on alluvial-sod soils;
- Wet low floodplain of a small river under a swampy sedge meadow on alluvial-sod soils;
- Wet low floodplain of the small river under the willow sedge on alluvial-sod soils;
- Low ridge floodplain of the small river under the willow wild hop on alluvial-sod soils;
- Low floodplain of the small river under the willow reed on alluvial-sod soils;
- Floodplain of a small river under a grass meadow with single white willow on alluvial-sod soils;
- High floodplain of a small river, complicated by shallow cut-in streambeds and cattle trails, under a meadow of ruderal-gramineous sedge on alluvial-sod soils;
- Dredging of the channel under willows of various grasses and gramineous on anthropogenic-bulk soils.

5. Conclusion
In the course of the research was given physico-geographical characteristics and detected landscape structure of a typical agricultural district of the north forest-steppe zone of the European part of Russia. The characteristic features of the landscapes are identified and described, an up-to-date floristic list is compiled, including 155 plant species, including 6 plant species listed in the Red List of the Nizhny Novgorod Region. The results obtained are of interest to regional and municipal authorities, land users, environmental protection, scientific and educational organizations.

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