Municipal Districts in the System of Landscape-Ecological Zoning of the Northern Sikhote-Alin

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Abstract. The process of landscape-ecological zoning of a large natural object makes it possible to represent spatial combinations of geosystems that perform the most important ecological functions. To preserve them at the level of municipal district government, it is necessary to identify ecologically significant landscapes that can be optimally used in the economy and at the same time be part of the regional system for preserving the natural environment. This is a case study of two municipal districts of Khabarovsk Territory – Vanino and Sovetskaya Gavan, their place in the landscape-ecological zoning of the Northern Sikhote-Alin, the dynamics of spatio-temporal changes in the categories of regional landscape-ecological zoning within these districts have been considered.

Keywords: geosystems, environment-forming and resource functions, landscape-ecological zoning, Northern Sikhote-Alin

1. Introduction

When solving problems at the regional level of planning, municipal districts are the main units of government within different constituent entities of the Russian Federation, for each of which the development of ecological network projects of the territory is carried out. The ecological network (natural network, landscape-ecological network), with all the variety of interpretations, is a system of territorial units that have intrinsic ecological value and perform certain ecological functions [1, 2]. Within the framework of a municipal district, this network, on the one hand, acquires a specific spatial manifestation, and on the other hand, it is part of the regional system for preserving the natural environment and maintaining natural balance in the conditions of economic development, which makes it possible to exercise control “from the top-down”. The landscape approach enables to use local level geosystems in combination with economic units (agricultural land, forestries, etc.) as spatial units.

To preserve geosystems of high ecological value (for example, key landscape areas), first of all, it is necessary to identify the territorial communities of geosystems based on a combination of physical and geographical factors, structural and functional features. This stage of research is called landscape-ecological zoning (LEZ), which covers the natural system of the rank of a landscape type or groups of terrain types. LEZ gives an idea of natural areas that perform ecological functions of different levels of significance, which must be accounted for in regional and municipal development programs. The purpose of this paper is: to provide an analysis of the territorial distribution of geosystems belonging to
different categories of LEZ and to consider the trends in its spatial and temporal structure (the ratio of
geosystems of varying degrees of change for the periods 1975–2010 and 2010–2020) via the case study
of two municipal districts of Khabarovsk Territory.

2. Materials and methods
The objects of the study were Vanino and Sovetskaya Gavan municipal districts of
Khabarovsk Territory, covering the eastern macroslope of the Northern Sikhote-Alin. The
total area of the territory is 41.5 ths km², which is 37.3% of the mountain system’s area
(Figure 1).

The assessment of the functional role of regional geosystems in the landscape structure
of the Northern Sikhote-Alin was carried out with respect to their natural and economic
importance. Almost everything in this mountainous region belongs to the category of
forest surplus territories, not only on the scale of Khabarovsk Territory, but also in the Far
Eastern Federal District as a whole. It is a zone of concentration of timber and non-timber
resources, hunting and fishing grounds. At the same time, the Northern Sikhote-Alin is a zone
of maximum biodiversity in the region, which indicates its highest environmental significance
not only at the regional, but also at the global level. Taking into account the available
classifications [3, 4, 5], the authors have identified three groups of functions
(environment-forming, resource-forming, environment-restoring), depending on the location of
geosystems with different levels of significance. Considering that the resource functions of ecosystems
should be considered with a more specific territorial reference, a system of the most significant resource-
forming functions is proposed specifically for these districts. Environment-forming functions are
considered as priority ones for the preservation of geosystems and reflect their role in the preservation
of the landscape as a whole and its individual components (biota, relief, etc.). The level of significance
of functions reflects the role in the ranking system: regional – for geosystems of a higher hierarchical
rank (up to landscape areas and regions), local – for particular geosystems.

The initial materials were a map of the Northern Sikhote-Alin landscapes developed by the authors
at a scale of 1:200,000 [6], the data on the areal and temporal characteristics of the transformation of
natural complexes in that territory under the influence of fires and logging, obtained on the basis of
interpretation of the Earth remote sensing data of medium spatial resolution (Landsat 3, 5, 7) for 1975,
1990, 2000, 2005, 2010 [7] updated according to satellite imagery data of 2020 (Landsat 8). The
materials were processed in the ArcGIS 10.5 software environment.

The significance of resource functions for each selected group of geosystems was assessed through
the contribution of the total indicator of the natural resource potential (NRP) of the territory of municipal
districts, expressed as its share (%), based on the methodology developed earlier by the authors [8]. The
assessment was carried out for 4 types of natural resources that play a significant role or are potentially
promising for economic use: forest timber and non-timber, commercial hunting and recreational
resources. Each of the types of resources was assessed on a 5-point scale, the results of the assessments
were summed up.
3. Results and Discussion
The landscape-ecological zoning carried out for the territory of the Northern Sikhote-Alin reflects the ecological functions of different levels of significance. In total, VI categories of geosystems have been identified, which form the basis of zoning, by the number of the most important characteristics of the landscape structure and by the priority functions of regional and local levels of significance. Figure 2 shows a fragment of the map for the districts under study, where geosystems with ecological functions of regional significance are highlighted. Table 1 gives a brief description of all groups of geosystems, the main environment-forming and resource functions and their share in the total assessment of the natural resource potential (NRP) of the districts.

Figure 2. Ecological functions of Vanino and Sovetskaya Gavan districts of Khabarovsk Territory of the Russian Federation. A. Environment-forming functions of regional significance (for the legend see Table 1). B. An assessment of the potential of resource functions (in points)
Table 1. Landscape-ecological zoning of research areas

| Degree of change in ecosystems, Significance level of functions. Geosystems groups | Ecological functions | Resource | Basic resources** | Geosystems areas, % |
|---|---|---|---|---|
| I | Conditionally unchanged and slightly changed. Functions of regional significance. | | | |
| 1 Mountain-taiga middle mountains | | | | |
| 2 Bald peak middle mountains | | | | |
| 3 Fir-spruce low mountains | | | | |
| 4 Fir-spruce with cedar low mountains | | | | |
| 5 Bald peak low mountains | | | | |
| 6 High plains and intermountain depressions with dark coniferous forests | | | | |
| 7 Floodplains of mountain rivers | L, W, Wpr, B | 4.1 | NT, H | 5.9 |
| II | Conditionally unchanged and slightly changed. Functions of regional and local significance. | | | |
| 8 High plains and intermountain depressions with dark coniferous forests; | E, B, W | 1.0 | T, R, H | 1.2 |
| 9 Lowland river floodplains; | B, Wpr, W | - | - | - |
| II | Conditionally unchanged and slightly changed. Functions of local significance. | | | |
| 10 Sites of the floodplain of mountain and plain rivers with meadow and meadow-forest communities | B, W | 0.5 | NT, H | 0.8 |
| 11 Foothill and marine plains with valley larch forests | B, W, Wpr, P | 0.1 | H, NT | 0.1 |
| 12 Floodplain expansions of mountain rivers with valley larch forests | B, W, Wpr, P | 1.4 | H | 1.6 |
| I | Moderately changed. Functions of regional and local significance. | 11.9 | H, R | 11.2 |
| V | | | | |
| 13 Middle mountain with coniferous-small-leaved forests | RD, E, W, B | 0.6 | H, R | 0.5 |
| 14 Low-mountain foothill and lowland coniferous-small-leaved forests | RD, E, W, B | 11.3 | H, R | 10.7 |
| V | Moderately changed. Functions of local significance. | 10.2 | H, R | 9.3 |
| 15 With small-leaved forests | RD, B | 9.9 | H, R | 9.1 |
| 16 Foothill and lowland with deciduous forests | RD, B | 0.3 | NT, R, H | 0.2 |
| V | Strongly modified. Functions of local and regional significance. | 32.4 | R, H, NT | 28.3 |
| 17 With burns of different ages | RD | 10.0 | R, NT, H | 8.1 |
| 18 With young post-pyrogenic forests | 16.7 | H, R | 15.6 |
| 19 Completed by fellings | 5.7 | R, NT, H | 4.6 |
| Total | 100 % | 100 % | | |
Figure 3. The areas of the transformed geosystems. 1 – burned out in 2011–2020; 2 – burned out in 1975–2010, not recovered; 3 – burned out in 1975–2010, recovered; 4 – felling areas of 2011–2020; 5 – felling areas of 1975–2010.

From the point of view of economic development, this territory is of great interest: the proximity of timber resources to the largest ports of Khabarovsk Territory and a rail connection made it possible to form the largest Vanino – Sovetskaya Gavan industrial hub. This undoubtedly had an impact on the decrease in the ecological and functional significance of geosystems. Medium-altered geosystems, which occupy about 20.5% of the area of the districts, along with the preserved environment-forming functions, also perform the environment restoration. The contribution of the investigated territory to the NRP is 22.1% (the main resources are hunting/fishing and recreational). The most changed geosystems occupy an area of 28.3%. Despite the disturbances in natural functioning, the contribution of resource functions is quite high – 32.4%, which is explained by their high biostation role, which contributes to the preservation of such resources as commercial hunting, as well as recreational and non-timber food and medicinal resources of the forest.
Of particular interest is the dynamics of areas disturbed by fires and logging (Figure 3). The fires that took place in the period from 1975 to 2010 led to the formation of large burnt areas – 19.4% of the area of the two districts. Of these, by 2020 the restoration of forest vegetation (young larch, larch-small-leaved and small-leaved forests) is observed in most of the areas affected by fire (54.5%). Over the past 10 years, the increase in the area of burned-out areas according to ERS data for 2011–2020 amounted to 1.15%. Thus, over these years, the annual increase in burned areas was 4.8 ths ha, which is 5 times less than this figure for the period 1975–2010 (23.1 ths ha).

The opposite view is observed in the area of felling: the average annual growth for 1975–2010 is 5.3 ths ha of felled areas, for 2011–2020 – 7.3 ths ha. The spatial pattern of felling distribution reflects a shift towards hard-to-reach middle mountains: in Vanino district to the north and especially to the north-east – closer to the coast of the Tatar Strait, in Sovetskaya Gavan – to the north-west and the east (Figure 3). For the period from 1975 to 2010, the share of middle mountains accounted for 2.1% of the area of felling, then in 2011–2020 it reached 5.9%. A similar tendency for the development of hard-to-reach territories is characteristic of the entire Northern Sikhote-Alin as a whole [7].

Large former burned-out areas are covered by the reforestation process, as a result of which young forests are formed there. At the same time, on large areas of volcanic plateaus, repeatedly traversed by fire, the formation of short-term secondary high-grass-shrub communities is taking place.

4. Conclusion
Landscape and ecological zoning reflects the ecological and functional significance of the geosystems of the two municipal districts of Khabarovsk Territory and the peculiarities of their spatial differentiation. Its implementation made it possible to identify a number of problems in the ecological situation in particular territories. Thus, the share of the total area of undisturbed geosystems (47.5%) is lower than the average for the northern Sikhote-Alin (50.4%), and in the category of highly altered geosystems it is 4% higher. The area of undisturbed geosystems decreases annually, which is associated with a stable increase in logging, shifting to hard-to-reach areas with highly vulnerable, ecologically valuable natural complexes (with absolute heights of more than 700–800 m above sea level). At the same time, the share of anthropogenically disturbed geosystems is gradually increasing, primarily due to an increase in the volume of logging and forest fires.

Conducting landscape-ecological zoning makes it possible, when creating ecological networks of municipal districts, to highlight geosystems of high ecological value at the regional and local levels, taking into account the functional role of geosystems of a higher taxonomic rank. Specially protected natural areas within the category of conventionally undisturbed geosystems of regional significance (category I in Table 1) occupy 26.8% of their surface area, which is insufficient to maintain optimal functioning. In the structure of this category of LEZ, groups of protected areas’ geosystems are represented unevenly: 24.2% falls on mountain taiga low mountains (Botchinsky reserve, Tumninsky and Mopau reserves), about 66% – on mountain floodplain geosystems (ecological corridors and ichthyological reserves), up to 10% – on the mountain-taiga middle mountains.

When shifting to a larger scale, optimal for municipal districts, additional field studies are required with a clear identification of contours within key areas in order to concretize the functional role of landscapes. These studies will allow developing regulations to take into account the regional and local value of specific geosystems. Classification of ecologically significant geosystems by priority environment-forming and resource functions, their representation in the ecological network of municipal districts will become an additional factor in the sustainability of the natural environment, the preservation of its landscape diversity and integrity.

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