ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

Landscape Mapping Of the Eastern Part of the Russian Plain.

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ABSTRACT

The use of landscape approach for the management of nature-use of the territory is substantiated. Structure of creating a geographic information database to identify natural territorial taxa of the rank of landscape region is developed. The main results of medium-sized landscape mapping of the eastern territory of the Russian plain (The Republic of Tatarstan). The analysis of the parameters that are used for landscape zoning is given. In total, for the purposes of landscape zoning more than 40 different parameters have been taken. On the basis of the method of artificial neural network by Kohonen landscape zoning is held. Ability to generalize is a valuable quality of artificial neural networks. Approaches to landscapes typification and their structures have been identified. The area of research that makes up to 68 square kilometers is divided into two landscape zones and four subzones and 31 landscape region. Implementation of mapping was carried out by means of GIS technologies. Well-defined boundaries of landscapes are formed during sharp changes of the natural environment. This type of borders is mainly conditioned by changes in bedrock lithology and geomorphological conditions. Geo information analysis of the prepared in vector format landscape map of the studied territory provides insight into the morphological structure of landscapes of different zones. Among them slope landscapes dominate, followed by valley types of areas and watershed ones occupy the least area.

Keywords: landscape, zoning, mapping, signs, morphology of landscape, Kohonen neural networks, river basins

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ISSN: 0975-8585

INTRODUCTION

Statement of the Problem: Resourcing of any territory is largely determined by its landscape features. The landscape gives a person not only some particular quality of environment, peculiarities of functional use of territories, but also determines the comfort of living of people, including their emotional state. With all the conventions held by the boundaries any territory can be differentiated into landscape complexes of different taxonomic rank. Each of them is inherent in a particular set of attributes, each of them has a certain ecological capacity and resistance to external adverse effects, it contains a particular resource and environmental potential. Landscape structure of the territory is reflected on maps that are actually synthetic [1] .. Despite the obvious value of the landscape approach, most of the territories of Russia to date do not have medium-sized landscape maps. The same applies to the eastern region of the Russian plain. In this context, medium-sized landscape mapping and zoning within the large area of territory (it administratively belongs to the Republic of Tatarstan) was the aim of our research. Zonal boundary separating two bio-climatic zones of temperate latitudes can be found in the studied region of the Russian Plain: Boreal (taiga and forest) and Subboreal (forest and steppe). The specificity of the region is also the presence of two major rivers: the Volga and Kama, creating natural boundaries and, as a consequence, discreteness of geosystems boundaries. According to the system of formed zonal boundaries the investigated territory was called "boreal ecotone" [2].

State of knowledge: The area of research has repeatedly served as a an object of landscape zoning. This is evidenced by zoning schemes and maps, compiled by A.V. Stupishin [3] A.G. Isachenko [4], Rysin [5], and others. All these zoning schemes are drawn up on the small-scale, very generalized cartographic basis and therefore require clarification.

If we talk about the morphological structure of the landscape, than a similar mapping virtually till the present time did not take place in the studied area. In this regard, we have set a task to create a landscape map for this part of the eastern part of Russian plain with the scale of 1: 200 000. In the course of landscape mapping the following material were involved: hypsometric map, diagram of geomorphological zoning, maps of soils and their granule content, plant formations, landscape map of the Soviet Union [4] and several others. Information of the genetic type of quaternary sediments was obtained using the materials of engineering and geological surveys. Morphostructural attribute landscapes was defined by their relation to the denudation plains of different ages.

MATERIALS AND METHODS

One of the most important, but also complex challenges of spatial analysis is to carry out the procedure of private and complex zoning. It involves a division of the territory in which the given taxa would at least meet the specifics of allocated operational and territorial units and interconnection of elements that saturate them.

As you know, when zoning we distinguish typological and regional approaches. In typological approach we take into account the most significant features characteristic of a particular taxonomic level of areas [6, 7], and omit many of their particular characteristics. The regional approach, on the contrary, suggests such a differentiation of territorial units, each of which is allocated on the basis of homogeneity and is characterized by clearly defined personality, their properties do not appear in the adjacent areas.

All previously created schemes of complex natural zoning relied on the use of standard "manual" methods that allow to take into account not more than 5-6 information layers on the basis of the classification of landscape conditions "top - down", ie from the general to the particular; or on the expert knowledge of the territory.

A new version of landscape zoning of the region is suggested. Creation of the boundaries of districts was carried out "from general to specific" and "from specific to general." The results of computer-aided private zoning of relief, climatic and landscape conditions, as well as analysis of the pattern of the landscape allowed to implement this principle. At the same time geospaces dissociated themselves so that within boundaries of each district values of natural and anthropogenic conditions that differ from the other sites were found.

During first phase automated typological zoning was carried out on the basis of classification of a large number of landscape features for the purpose of pointing out "cores" of areas with various taxonomy [8]. For the construction of classes the Kohonen method of neural networks was used [9], which was programmed by A.A. Savelyev. This method can be considered a generalization of the method k-means, which allow to represent topological properties of received classes in the space of features, and hence the structure of the whole space of features on this territory. In the proposed by Kohonen self-organizing images the classes are represented as reference elements. The main difference from the traditional approach is that all the classes are arranged in advance in a regular rectangular lattice and distance in which is used in the process of learning and self-organization of a neural network. The use of a neighborhood in the lattice when changing classes leads to the fact that the centres of adjacent classes of lattice become close in the space of features. If the self-organization process is successful, the two classes will be similar in feature space if and only if they are close in lattice classes. In this case it is possible to display the grid plane so that the distance between the image plane classes coincide with the distances between the classes in the feature space [10]. The resulting representation carries all the information about the structure of the feature space used relative measure of distance and reveals the "core" - the area in the feature space, the most abundantly represented in the territory [11]. Moreover, the diverse properties of the territory associated with space also turn out to be thematically ordained on the plane and available for analysis of their connection with various combinations of features. The advantage of this method is the large number of "degrees of freedom", which allows to build arbitrarily accurate models, as well as the ability to "self-learn", that is to correct its own structure and "behavior" taking into account incoming data.

When forming systems of signs for landscape zoning, we wanted to ensure that they cover taking into account the size of the territory the necessary hierarchy of geosystems that they had enough variety and their values and were accessible for measuring in order to obtain mass discrete material. For the purpose of study of spatial organization of landscape conditions of the region, we took into consideration both zonal and regional factors of territorial differentiation. When doing information evaluation of geocomplexes of regional level we used the known principle of "black box." According to it as "input" parameters, defining the spatial differentiation of landscapes, we chose landscape-geophysical, geological and geomorphological and biotic features. The combination of these features form according to E.G. Kolomyts [2] blocks of cybernetics model of natural complex, consisting of a landscape frame of zone geospaces and the so-called processing unit, describing the nature and intensity of various geo currents inside the spaces themselves.

For zoning as landscape-geophysical features the following parameters were used: the annual total radiation; radiation balance; hydrothermal coefficient; the sum of active temperatures; factor of continental climate; module of average annual high water runoff; runoff coefficient; annual precipitation sum; gross territory moisturizing; water reserves in snow cover and a number of others.

From the geological and geomorphological features such characteristics took part in zoning: density and depth of valley dissection; granulometric content of soil; composition of underlying bedrocks; average steepness of elementary river basins; distribution of relief according to the stages of absolute heights; density of diluvial and solifluction loam and others.

Primary productivity of landscapes is included in the biotic unit. In interpretation of D.L. Armand, this characteristic can be regarded as an integral landscape-geophysical indicator of geosystems functioning.

We included such indicators in the "output" block of geocomplexes of regional level as subtypes of soil and humus reserves, forest cover, basins blanchness, types of plant formations that allow zonal and regional indication of types of landscapes and that are their important diagnostic signs.

In total, for the purposes of landscape zoning more than 40 different parameters were taken.

The used procedure of computer allocation of homogeneous areas because of level of detail and diversity of aspects of source information and analysis of features allowed us to escape from the inevitable generalization and subjectivism that we face with traditional methods of zoning. "Manual" methods of zoning in the allocation of boundaries of regional taxa are oriented by natural indicators inherent in upland locations. Meanwhile, under condition of strongly dissected plains share the upland soils is extremely small (3.5 - 6%),

and in the agricultural area they have long been plowed. For example, in Tatarstan only 0.9% are located on watersheds of the total forest area, and taking into account highland near the water sites 3.7%. The types of terrain slope, whose landscape conditions considerably differ from the flat spaces of watersheds are predominant (over 75%). All this inevitably calls for questions to the representativeness of obtained zoning schemes. In the scheme of zoning provided by us, we tried to avoid these shortcomings.

Initially using a neural network method based on the analysis of information, geographically tied to river basins. The boundaries of river basins were allocated using different algorithms of analysis of global digital models [12, 13, 14]. By its dimensions and individual characteristics the received classes correspond to the type (or class) of landscape.

RESULTS

In accordance with the classification of A.G. Isachenko [6], identification of boundaries of zonal-sector landscape types was conducted. Inside them landscape areas that are related to one or another high altitude level class are positioned. Depending on the distribution of altitudes in the region of research they are sub-divided into subclasses of the elevated ones (height of more than 160m) and low ones (height less than 160m). Within the areas according to individual combination of all parameters taxa of lower rank are located - types of terrain (or landscapes themselves). Types of landscape correspond to the classes of neural network on the first stage of zoning and are the basic "building blocks" with the help of which all subsequent zoning was conducted.

Table 1: The morphological structure of landscapes of the East of the Russian plain (within the Republic of Tatarstan)

Types of terrains	Landscape zone	
	Boreal	Subboreal
Watershed	6,54	3,54
Slope:		
Highland near the water parts of slopes	15,23	15,11
Middle parts of slopes	35,53	37,17
Lower parts of slopes	22,97	24,78
Valley:		
High terraces of little rivers (3, 4)	0,22	0,78
Low terraces of little rivers (1, 2)	2,46	3,58
4 terrace of little rivers	2,56	2,41
3 terrace of little rivers	2,54	0,93
1, 2 terraceS of little rivers	1,44	2,79
Slopes of terraces of little rivers	0,43	0,69
Flood plain	10,08	8,22

The received landscape boundaries generally correspond to the borders of areas, tortuosity of which is largely determined by the configuration of the river basin. During zonal and subzonal boundaries creation habitats were generalized that consist of several small basins, typologically homogeneous, but located in isolation from the main core area. The boundary between the boreal and subboreal area is drawn taking into account the distribution of leading climatic and landscape indicators in the buffer strip 50 km wide, some of which are integral. In particular, the value of the radiation index of dryness that acts within the limits of temperate zone as a kind of indicator of optimum of "natural biological productivity", varies from 0.95 to 1.2 with the mean value of 1.09. The amount of active temperatures ranges from 2086 ° C to 2197 ° C with an average value of 2142 ° C. The total rainfall varies from 579 to 611 mm with an average of 595mm. The annual

radiation balance changes from 1474 mJ/m^2 to 1674 mJ/m^2 with an average of 1574 MJ/m^2. Hydrothermal coefficient is in the band of values from 1.57 to 1.77 with a mean of 1.67.

The area of research is divided into two landscape zones, four subzones and 31 landscape area. A comparison of the zoning scheme gives an idea of existence of different types of borders between geosystems of different taxonomic level. Well-defined boundaries are formed with a sharp change in natural conditions. This type of borders is mainly conditioned by the change in lithology underlying bedrocks and geomorphological conditions (relief morphometry and its genetic types). As an example we can provide territories adjacent to the valleys of major rivers (the Volga and the Kama) that form clear linear boundaries. The same kind of borders is identified in high Eastern Zakamye in Tatarstan due to a well-defined layering of denudation relief.

Against the background of weak differentiation of relief homogeneous lithology of soil ecotone character of geosystem borders is already widespread. Such boundaries are formed because of smoothness of changes in hydro-climatic parameters in conditions of a flat terrain. Continual type of boundaries of zonal level is most pronounced in the Volga region. Another large-scale continuum boundary, but only between the lowland and upland subclasses of forest-steppe landscapes runs in the Volga region.

Geoinformational database compiled for the landscapes of the territory and the use of GIS technologies for the first time allowed to quantify the morphological structure of landscapes for the studied area (Table 1), to map the human pressure on natural systems in landscape areas.

SUMMARY

Using a large set of parameters characterizing natural diversity of the territory and a new method of semi-automatic classification - neural networks – allowed to get landscape zoning of a large region of Eastern part of the Russian plain. Analysis of the parameters of the geocomponents allowed to establish different types of landscape borders. Geoinformational analysis of the created in vector format landscape map of the studied territory provides insight into the morphological structure of landscapes of different landscape zones. Among them slope landscapes dominate, followed by valley types of terrain and the smallest development area is occupied by watershed landscapes.

CONCLUSIONS

In the article the structure of creating a geoinformational database to identify natural and territorial taxa of the rank of landscape area has been justified. The analysis of the parameters to be used for landscape zoning is given. On the basis of the method of artificial neural network by Kohonen landscape zoning of the territory with more than 40 parameters usage has been conducted. Valuable quality of artificial neural networks is the ability to generalize. Approaches to landscapes typicality and their structure have been identified. For the studied territory allocation of borders of the two landscape zones, four subzones and 31 landscape area has been justified. Well-defined boundaries of landscapes are formed during a sudden change in weather conditions. This type of borders is mainly conditioned by the changes in lithology underlying bedrocks and geomorphological conditions.

CONFLICT OF INTEREST

The author confirms that the data do not contain any conflict of interest.

ACKNOWLEDGEMENT

The work is performed according to the Russian Government Program of Competitive Growth of Kazan Federal University. The work is performed according to the Russian Science Foun-dation (project №15-17-10008).

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