


LANDSCAPE ANALYSIS FOR SUSTAINABLE DEVELOPMENT

Theory and Applications of Landscape Science in Russia


LANDSCAPE HIERARCHY AND LANDSCAPE DIVERSITY (CONTACT ZONES OF LOWLAND AND MOUNTAIN COUNTRIES AS A CASE STUDY)

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Introduction

Classification has always been one of the most important focuses of landscape science. Much consideration has been given to consistency of classification as it affects the results of further spatial analysis. D.L. Armand (1975) emphasized that one should make a distinction between the "vertical" classification of objects (referred to as taxonomy, hierarchy or hierarchical classification) and the "horizontal" separation of the equal rank objects (referred to as typology or typological classification). Hierarchy, as applied to geographical objects, is considered as the subordinated relations among the systems of different rank order (Isachenko, 2004). Although each territory has a unique landscape hierarchy, it is convenient to specify a number of general levels as well as the characteristic features for each level, to establish the scale of natural phenomena manifestation.

Accordingly, there are two viewpoints that might seem to be opposite at first glance, but, in our opinion, are not mutually exclusive. In general, one can argue that size, i.e. the area of detection, is one of the important diagnostic features of the geosystem of definite rank order. As a rule, the lower is the geosystem rank, the smaller is its size. However, it is difficult to disagree with N.A. Solntsev (1962), that not the area, but inner complexity of the object is the most crucial attribute. If this idea is accepted, one should assume that most landscape-forming factors, depending on their degree of manifestation, could act as the criteria of geosystem identification at different taxonomic levels. Indeed, it has been noted repeatedly (e.g. Puzachenko, 1997) that the concept of a level-specific key factor is an essential simplification of reality. The peculiarities of local geology, solar and circulation aspect, erosion-accumulation behavior of glaciers or water flow are the factors that cause the differentiation of geosystems with various sizes and inner complexity. With that understanding, the more proper way is to speak not about key factors, but about indicators of individual and typological features of a specific geosystem, thus defining its hierarchical position.

This statement is clearly illustrated by the analysis of landscape structure of adjacent plain and mountain regions. Evidence shows that due to a difference in heat supply and the relation between solar heat and precipitation, a 100 m increase in elevation is equal to a 100 km long movement towards the pole. Hence, in plains, the quantitative variation of heat and water supply results in a qualitative change of landscape structure corresponding to the zonal or sector gradients. Thus, large regional-level units originate. However, the inter-landscape differentiation is determined by the other factors. When approaching the mountains, the relationship between heat and precipitation changes at shorter distances because of the barrier effect. Therefore, zonal and subzonal stripes on the piedmont plains and foothills have a reduced width. This allows us to conclude that an indicator such as the relation between heat and precipitation on flat sites becomes a landscape-forming factor on the lower level of landscape hierarchy. The manifestation of this factor depends strongly on the orientation of the mountain system and the specific character of the boundary between mountains and plains. For instance, on the Pre-Altay plain, the subzonal differences in soil and plant cover are the main factor of geosystems differentiation on the lowest regional level, referred to as *physical-geographical districts*. This interpretation of zonal and subzonal differentiation on the piedmont plains is a complementary criterion allowing for their consideration in the framework of the mountain zoning schemes, despite the fact that the physiognomic features of topological level piedmont geosystems are often similar to those of plain ones. In the mountains, the changes in relations between heat and precipitation similar to the latitudinal ones take place as the elevation increases but at the smaller distance. In effect, the altitudinal-zonal differentiation in particular mountain regions characterizes the mesoposition. As a result, the same factor manifests itself at the other level of spatial differentiation by shifting from the regional level to the topological level.

Insufficient consideration of the aforementioned ideas results in the incorrect characteristization of the landscape structure, in particular, landscape diversity. Landscape diversity is understood as a number of one-rank geosystems within the landscape (Beruchashvili, Zhuchkova, 1997) or any territory in general. However, in regional studies, landscape diversity is often confused with the other attributes of the landscape structure, complexity and divisibility in particular. For instance, while analyzing territories involving both plain and mountain landscapes it is argued that landscape diversity increases from plains towards mountains. Quite often the roots of this opinion may be traced back in ignorance of geosystems rank order, which is necessary in evaluating diversity. It is inconsistent to compare the *mestnost* level diversity in one landscape with the *urochishche*[23] diversity in another.

Additional difficulties often arise when the notions of flat automorphic (zonal) and dominating positions are confused. For example, slopes dominate on the margins of the highly dissected Ob' plateau adjacent to the Ob river valley, while flat automorphic terrains occupy only a small part of the territory. When comparing vegetation on the slopes with that on the flat automorphic terrains, the researchers sometimes make wrong conclusions about the territorial zoning. Very often, in mountains and on the foothills as well, one can hardly find flat automorphic (*plakor*-like, *sensu* V.S. Mikheev, 1987) locations which are characterized by a pure effect of a certain altitude

Indeed, as mentioned above, the differentiation of geosystems of the same hierarchical level at different sites can depend on different factors. The altitude-belt differences in the mountains are often of primary importance in the determination of high-level areas (Miller, 1974). Under low dissection on the plains, the *mestnost* level units are identified based on other attributes of mesoposition. It is in this way that F.N. Milkov (1981) distinguishes the flat automorphic, hillside, terrace, flood-plain types of *mestnost*. In other conditions these factors either transfer to the lower level (flat automorphic (*plakor*-like) *urochishches* and *facies*[24] in the mountains), or raise their rank (a number of high-level *mestnosts* can be found on the long mountain slope).

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[23] For definitions see (Dyakonov, 2007, this book).

[24] For definitions see (Dyakonov, 2007, this book).

Study area and results

To compare the indicators of landscape diversity we have analyzed landscape maps of five key sites. The study areas are located in the south of the West Siberia lowland and within the Altay mountain region: the Alei river basin, the Barnaulka river basin (Zolotov, Chernykh, 2005), the Kurai intermountain depression (Chernykh, 2000), the Teletskoye lake basin excluding Chulyshman river (Chernykh, 2001) and Bystroistoksky administrative district of the Altay region (Chernykh, Zolotov, 2006, in press). The maps (1:200 000) have been complied following a unified methodology. As the largest morphological landscape units, *mestnosts* were chosen as the main units for mapping.

Many researchers (Isachenko, 1991; Mamay, 2005) have noted a variety of reasons by which one *mestnost* can be distinguished from the other one. Therefore, it is rather difficult to find a single criterion for their identification. That is why *mestnosts* are often considered the optimal units of landscape morphological structure. While mapping landscapes in Altay and southern West Siberia we assumed that both on the plains and in the mountains the landscape should be uniform in its basic climatic and geological-geomorphologic parameters determined by the main sources of energy, solar energy and inner energy of the Earth. In terms of structure, landscape corresponds to the positive or negative macroform of relief. Mestnost is considered as the rank order of geosystems with positional similarity within a specific element of the relief macroform (Nikolaev, 2000) that provides homogeneous conditions for the formation of *urochishches*. By using such an approach, *mestnosts* may be easily identified. Studies on landscape mapping suggest that the area of *mestnosts* may vary between 1 and 1000 km^2 (Vinogradov, 1981). Our research shows evidence that the area of most *mestnosts* falls within the range of 10 to 350 km^2.

The first study site, the Alei river basin, is located within two *physical-geographical countries*, namely West Siberia lowland and the Altay-Sayan mountains. The basin area is 19262.8 km^2, and 64 types of *mestnosts* have been identified there. Thus, the diversity of terrains amounts to 3.32 per 1000 km^2 (Table 1).

Table 1. Landscape diversity in model regions

Region	Area of mapping, km^2	Number of mestnost types	Diversity of mestnosts per 1000 km^2
Alei river basin Including	19262.82	64	3.32
Lowland	11959.69	36	3.01
foothills and low mountains	7303.13	28	3.83
Barnaulka river Basin	5787.14	40	6.91
Bystroistoksky region	1834.99	17	9.26
Kurai depression and its mountain frame	3052.00	39	12.78
Lake Teletskoye basin (excluding Chulyshman river)	2433.39	15	6.16

The lowland part of the Alei river basin crosses the following four subzones (upstreamward): south forest-steppe, moderately arid steppe, arid steppe and dry steppe. The upper reaches of the basin are located in the arid- steppe and moderately arid-steppe foothills, steppe, forest-steppe and subtaiga (*chern*) low mountains. Subzonal division of mountain-steppe and mountain-forest-steppe landscapes was not carried out since the relationship between heat and precipitation changes over such a short distance that subzonal differences cease to serve as indicators at the *mestnost* level. Across the entire region landscape diversity appears as follows. In the lowland part of the basin, the subzone of the south forest-steppe, there are 8 types of *mestnosts*, 11 types of moderately arid steppe, 10 types of arid steppe and 7 types of dry steppe. In the foothills and low mountains landscape diversity features: the piedmont arid steppe – 6 types of *mestnosts*, piedmont moderately arid steppe – 10 types, steppe lowland – 2 types, forest-steppe lowland – 6 types, *chern* lowland – 4 types. On the whole, the landscape diversity on the *mestnost* level in the lowland part of the Alei river basin amounts to 3.01, and in the foothills and low mountains – 3.83.

The second study site, the Barnaulka river basin, is located within the West Siberia lowland country and runs parallel with the low part of the Alei basin. Its valley subsystem is formed from the bottom of the ancient runoff valley. Highland watershed separates it from the Alei river valley, on the one side, and from the Kasmalinskaya valley of the ancient runoff, on the other. The Barnaulka river basin crosses three subzones: forest-steppe, moderately arid and dry steppes. The total landscape diversity amounts to 40 types of *mestnosts*; the diversity of 6.91 per 1000 km^2 is two times higher than in the Alei basin. As for subzones, the diversity in the Barnaulka basin is as follows: south forest-steppe – 19 types of *mestnosts*, moderately arid steppe – 12 types, and the arid steppe – 9 types.

The third key study site, Bystroistoksky region, is of particular interest since it is located in the forest-steppe zone (subzones of central and south forest-steppe). The southern part of the region occupies a part of Pre-Altay piedmont plain (subzone of south forest-steppe); its northern part is located in the terraced valley of the Upper Ob (subzone of the central forest-steppe of the West Siberia lowland). The Ob floodplain comprises a considerable part of the region. The total landscape diversity consists of 17 *mestnosts*; incredibly, six of them are situated within the *mestnost* of the Ob floodplain. On the whole, the landscape diversity amounts to 9.26 per 1000 km^2, in the lowland it is 7.59 and it rises sharply up to 13.54 in the piedmont.

The analysis of mountain landscape diversity took place in two contrast regions of the Altay mountain country, the Kurai intermountain depression including its mountain frame, and the Teletskoye lake basin (excluding the Chulyshman river basin).

The Kurai depression is particularly attractive since it is located on the border between the Central Altay and South-East Altay *physical-geographical provinces*. It is for this reason that the typical features of both provinces are combined in landscapes. Various landforms favor the influence of Altay-Sayan (Central Altay) and Mongolian (South-East Altay) nature to different extents. The lower belts show mainly dry and continental conditions of Central Asia, while the upper ones are characterized by a cyclonic regime. Earlier we referred to this region as a regional geoecotone (Chernykh, 2000). In such contrastive conditions the landscape diversity amounts to 39 types of *mestnosts* in a rather small area of 3052 km^2. Consequently, an area of 1000 km^2 will present 12.78 types of *mestnosts*[25].

The fifth object of investigation was the the Teletskoye lake region. In this 2433.39 km^2 area 15 types of *mestnosts* (6.16 per 1000 km^2) were found.

Conclusions

The data we have obtained allows us to make the following conclusions:

1. The comparison of landscape diversity is possible only for similar levels of landscape hierarchy.

2. The widespread view that landscape diversity increases from lowlands to mountains requires considerable correction. According to our data from the Teletskoye lake region, which is one of the most deeply dissected in Altay, landscape diversity here is two times less than around the Kurai depression, the values being very close to those for the Barnaulka river basin. This supports our hypothesis that high values of landscape diversity do not necessarily correspond to the high divisibility of landscape structure. This conclusion is in good agreement with G.S. Samoilova's (2002) data concerning the comparison of landscape diversity for specific sites in the north of Interior Asia. She has noted that landscape diversity (diversity on the *landscape* level) in the peripheral "cyclonic" provinces is insignificant as compared to the interior ones. However, the landscape diversity indices grow at the level of morphological landscape units.

3. Regions with similar background conditions can exhibit different landscape diversity depending on specific conditions. For instance, in the Barnaulka basin the terrain diversity increases downstream from the arid steppe (9) to the moderately arid steppe (12) and south forest-steppe (19). This is due to the intensification of erosion-accumulation processes in the main stream and approaching the Ob valley, which exerts great matter, energy and information influence on the basin landscapes. On the other hand, in the Alei basin the largest landscape diversity is detected in the subzone of moderately arid steppe (11 types in the lowland and 10 types in the piedmont). *Mestnost* diversity reduces both towards the outlet (8 types in south forest-steppe) and upstream (2, 6, 4 types of terrain for steppe, forest-steppe and *chern* lowland, respectively). The junction of the Altay and West Siberia lowland structures determines maximum diversity in the moderately arid steppe.

4. The stream order and the area of river valleys are of great importance for landscape diversity. Interestingly, whereas in cases of small rivers the whole river valley is treated as the *mestnost*; in medium-sized rivers, we deal with floodplains, complexes of low and high terraces, and in large rivers, such as the Ob, each terrace acts as the independent *mestnost*. Some of them can even contain several types of *mestnosts*. Undoubtedly, the floodplains of large rivers include several *mestnosts* (even within a single landscape).

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[25] To compile a landscape map for the study area we have used geomorphological materials collected by I.S.Novikov (1994).

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