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RESEARCH ARTICLE

Landscape diversity as an attraction basis in the design of tourist and recreational areas (the case of Bolshaya Belokurikha)

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Abstract

The article discusses the assessment of landscape diversity and biodiversity in a projected tourist-recreational territory. Bolshaya Belokurikha, located at the junction of the Altai plains and mountains, is used as a case study to illustrate the significance of these factors. The study area covers a 40 km section from Makaryevka to Krasny Gorodok villages, which attracts more than 250 thousand tourists annually due to its favorable climatic conditions and landscape diversity. The authors use modern methods, including mathematical modeling and spatial data analysis, to develop a GIS model of landscape diversity using the Shannon method of numerical entropy estimation. The model is presented as an isolinear map for cartographic visualization. The authors emphasize the importance of natural and ecological elements in the tourist frame of the projected area. They also propose considering landscape diversity as a stimulating factor for tourism development and as a basis for sustainable development of tourist territories in a two-level design, which includes the tourist-recreational complex and tourist area. To efficiently use the potential of the territory and ensure maximum preservation of existing landscapes, the authors suggest using constructed maps and GIS models of landscape diversity and biodiversity as a basis for functional zoning of the territory. This approach would help identify areas suitable for tourist development while also preserving the flora and fauna species diversity. Overall, the article provides a comprehensive approach to the sustainable development of tourist-recreational territories. By using modern methods and GIS models, the authors demonstrate how landscape diversity and biodiversity can be integrated into the planning and management of tourist areas, leading to a more sustainable and responsible approach to tourism development.

Keywords

Landscape diversity, biodiversity, attractors, Bolshaya Belokurikha, GIS technology, numerical simulation, tourist-recreational design

Introduction

In designing sustainable tourist and recreational territories, it is crucial to consider the landscape's diversity and aesthetic attractiveness since it has a significant impact on the recreational potential (Carwardine et al 2020; Dirin, Bykov 2011; Dirin 2013; Arroyo-Rodriguez et al. 2020). Our research aims to identify promising tourist areas by exploring landscape diversity and aesthetic attractiveness.

The integrated approach is among the primary methods for designing tourist territories, combining natural tourist resources with available cultural and historical objects and infrastructure (Conlisk et al 2005; Drielsma et al 2007; Ferrier, Drielsma 2010). Landscape complexes can serve as the foundation for diverse tourist projects. The comprehensive assessment of the tourist and recreational potential of a territory involves analyzing the total recreational value of territorial complexes by means of special point estimates related to the landscape features and their attractiveness (Knight et al. 2005; Jurasinski et al. 2009; Gonzalez et al. 2020). To evaluate the comfort of the territory for tourism development, the aesthetic factors of the landscape, such as landscape diversity and aesthetic attractiveness (Yakovleva 2015), are essential. Assessing landscape aesthetics involves evaluating the aesthetic qualities of natural formations, which play a crucial role in tourism organization. The scenic beauty of an area is determined by landscape components, including terrain with geological features, vegetation cover, water bodies, alternation of open and closed spaces, view panoramas, and colorful diversity of landscapes (Justus, Sarkar 2002; Kuskov 2008; Heydari et al. 2020). The value of each landscape element is necessary for the sustainable development of the tourist area, requiring functional zoning of the whole territory and its components.

Studying landscape diversity is vital because it creates conditions for the formation of biological diversity, and consequently, landscape attraction. Evaluating landscape aesthetics is important in recreation because beauty in nature is objective and can evoke similar emotions in different people. Attempts are being made to develop a set of objective criteria for quantifying the aesthetic qualities of landscapes (Moffett, Sarkar 2006; Haines-Young, Potschin 2010; Marchese 2015; Kremen, Merenlender 2018).

Assessing landscape aesthetics based on the comparison of natural areas in terms of their attraction is important in recreation. Beauty in nature is objective; it is not a matter of taste and may evoke the same feelings in different people. Thus, attempts to unify the systems and criteria for such evaluations seem to be quite correct. In this case, aesthetics is considered as the degree of emotional appeal of a territory (Tittensor et al. 2014; Pullin et al. 2016; Mukherjee et al. 2018). A modern methodology for assessing the landscape-forming significance of elements is based on revealing and analyzing the influence of visual qualities of natural territories and nature elements on human emotions (Palmer et al. 2016). Currently, the development and improvement of methods for expert evaluations are of great interest. Several attempts were made to find a set of objective criteria to qualify landscape attractiveness more precisely than based just on individual taste. Most of these techniques involve a quantification of the aesthetic qualities of landscapes (Canham et al. 2003; Ball et al. 2009). Among them, the most widespread ranking

method based on the estimate of individual recreational qualities of landscapes and the peculiarity of their combination (Carwardine et al. 2009; Haines-Young, Potschin 2010; Heydari et al. 2020).

Our research aims to analyze and interpret the landscape diversity of Bolshaya Belokurikha using GIS technologies, and propose recommendations for designing tourist and recreational areas.

Material and methods

The tourist zone of Bolshaya Belokurikha encompasses the foothill plain and low mountains within a radius of about 15-20 km from the Belokurikha resort, which offers stunning landscapes, powerful natural recreational potential, and medicinal mineral waters. Field studies have identified the most attractive sites for the construction of tourist infrastructure facilities and the creation of a major tourist complex. Located at the junction of the Altai plains and mountains, Bolshaya Belokurikha is one of the projected tourist-recreational territories in Altai Krai. Covering a 40 km section from Makaryevka to Krasny Gorodok villages, the natural potential and unique natural objects in the area attract over 250,000 tourists each year due to favorable climatic conditions and landscape diversity that ensures a wide range of species composition.

To analyze the tourist-recreational territory spatially, geoinformation mapping is essential for the visualization of landscape diversity indicators of areal units of natural complexes or landscapes and identification of their complexity, mosaicism, and discreteness. The landscape geoinformation mapping process involves a unified scheme-based collection of initial information, its mathematical processing, and cartographic visualization of derivative electronic maps according to a previously approved method. However, transitioning to such evaluation requires other methodological approaches and indicators to reflect landscape diversity in information-cartographic and GIS-models most fully and objectively. A whole system of indicators is formed by information and statistical indices, including the "Macintosh" measure proposed by Mackintosh, which considers a community as a point in a multidimensional hyperspace with coordinates (n1, n2, n3,..., nS), and the Euclidean distance of the community from the coordinates origin can be used as a measure of its diversity U:

$$U = \sqrt{\sum n_i^2};$$

where n_1 is the number of individuals of the i-th species.

Using this index, one can calculate a measure of diversity (or dominance) – D:

$$D = \frac{N - U}{N - \sqrt{N}};$$

where N is the total number of individuals.

Next, the Pielou index (E) is calculated using the formula:

$$E = \frac{N - U}{N - N/\sqrt{S}};$$

where S – the number of species identified.

There are some other indices that characterize diversity. The processing of statistical (diversity) data allowed researchers to suggest more than 20 indices. As a result of a comparative analysis of these indices, Y.A. Pesenko (1982) revealed a

correlation between many of them that confirms the objectivity and possibility of assessing diversity.

Based on the comparative analysis of diversity data obtained by different authors, Magurran (2013) recommended calculating the Shannon index (H).

For numerical estimate and development of the model of spatial diversity in GIS, we used the Shannon index (H) derived by the formula of Shannon (1963):

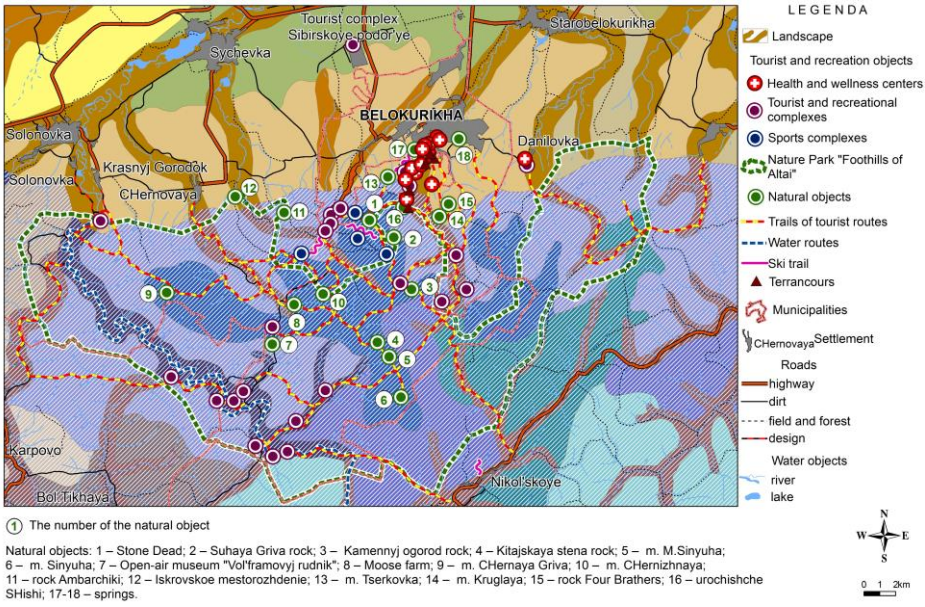
$$H' = -\sum_{i=1}^{N} P_i \ ln \ P_i,$$

where P_i is the proportion of individuals (units) of the i-th species, Ni is the number of individuals (units) of the i-th species, and N is the total number of individuals (units).

In formulas, a binary (log_2) is often used instead of a natural logarithm.

To better understand landscape diversity, indicators calculated by the Shannon formula can be used, allowing for the analysis of landscape diversity in unified measurement units using geoinformation methods. This approach can establish links between different types of diversity in the natural environment (Baryshnikova and Krupochkin, 2006, 2007, 2009).

Bolshaya Belokurikha encompasses the resort territory, the natural park 'Altai Foothills,' and surrounding flat and mountain areas. As one of the main tourist areas in Altai Krai (see Fig. 2A), the landscape varies from partially open to connected in all directions with medium and long-range plants as visitors move across the territory. The area integrates piedmont plains with grassland steppes, valleys of small rivers and streams with herbaceous meadows, and tree and shrub thickets of the Pre-Altai province (part of the west Siberian landscape country) with dividing and dissected (rocky in places) surfaces covered with diverse forests of the North Altai province (part of the Altai-Sayan Mountain Country, see Fig. 1).



① The number of the natural object

Natural objects: 1 – Stone Dead; 2 – Suhaya Griva rock; 3 – Kamennyj ogorod rock; 4 – Kitajskaya stena rock; 5 – m. M.Sinyuha; 6 – m. Sinyuha; 7 – Open-air museum "Vol'framovyj rudnik"; 8 – Moose farm; 9 – m. CHernaya Griva; 10 – m. CHernizhnaya; 11 – rock Ambarchiki; 12 – Iskrovskoe mestorozhdenie; 13 – m. Tserkovka; 14 – m. Kruglaya; 15 – rock Four Brathers; 16 – urochishche SHishi; 17-18 – springs.

Figure 1. Belokurikha landscapes (according to Vinokurov 2016)

Results

Bolshaya Belokurikha is a popular tourist destination in Altai Krai, encompassing the resort territory, the natural park 'Altai Foothills,' and surrounding flat and mountainous areas. The landscape scenery varies as you move through the region, transitioning from partially open to completely open, with medium- and long-range views connecting in all directions.

The area comprises piedmont plains with grassland steppes, valleys of small rivers and streams, and herbaceous meadows intertwined with tree and shrub thickets of the Pre-Altai province, which is a part of the West Siberian landscape country. Additionally, the traversed dissected surfaces are covered with diverse forests from the North Altai province, which is a part of the Altai-Sayan Mountain Country (see Fig. 1).

To promote tourism, a diverse range of landscapes and their visual appeal are essential. Bolshaya Belokurikha boasts natural attractions such as geological formations like the Sukhaya Griva rock with its spring, the intricate Four Brothers, the Belokurikha granite block complex called Ambarchiki, the isolated granite massif Ogorodchiki, the Chinese Wall, and Malaya Tserkovka (815 m a.s.l.) - a popular sightseeing spot. The area's flora also plays a significant role in tourism, with pine, oak, linden, and aspen-fir forests, along with 34 rare relic species of broad-leaved forests, tallgrass mountains, and lowland cereal-hellebore meadows creating an atmosphere of harmony and aesthetic pleasure.

Water bodies such as the Peschanaya and Poperechnaya rivers add to the area's appeal. The Peschanaya River, with its varied landscape of taiga forests in the south, open mountain valleys in the southwest, a canyon in the west, hilly plains in the northwest, and flat terrain in the north, meanders around Bolshaya Belokurikha. The Poperechnaya River originates from Malaya Listvennaya, close to the old Botunovsky tungsten mine, and flows around Bolshaya Belokurikha from the east and northeast, creating beautiful landscapes.

Bolshaya Belokurikha benefits from a diverse range of landscapes, which are crucial for tourism development. These landscapes are enhanced by geological formations, including Sukhaya Griva rock, ‘Four Brothers’ geological formation, Ambarchiki rock complex, Ogorodchiki granite massif, ‘Chinese wall’ granite massif, and M. Tserkovka. Plant life also contributes to tourism, with primroses, pine, oak, linden, and aspen-fir forests, and 34 rare relic species of broad-leaved forests creating an atmosphere of harmony and aesthetic pleasure. The area’s water bodies, such as the Peschanaya and Poperechnaya rivers, also offer picturesque landscapes that attract tourists.

The Belokurikha River, which originates from M. Sinyukha, the highest mountain in the Belokurikha granite massif, offers the best health routes. The Chernovaya River, originating near the historic Belokurikhinsky mine, is another popular tourist site. The Bolshaya-Sychevka River flows near the projected new resort complex, Belokurikha 2 - Gornaya, and is part of the picturesque site of the Ogorodchiki rock massif. Mineral waters called Iskrovskiye are well-known near the plain outlet, and there is a beautiful pond in the flat part of the village Sychevka.

The favorable natural, climatic, and landscape conditions of Bolshaya Belokurikha are used for balneological and recreational purposes, and tourists can enjoy activities such as hiking, skiing, horseback riding, and boating. A visual isolinear

model was created using the authors' method to estimate the entropy diversity measure, which is essential in designing attractive tourist sites. This method is based on the Shannon information theory and ensures that measurement units are either preserved or reduced during mathematical transformations.

Derivative digital maps of landscape diversity, slope exposure and steepness, and solar insolation conditions were constructed based on the base landscape map and SRTM digital elevation model. Studying biodiversity within landscape boundaries provides a streamlined approach to statistical data and allows for consideration of real diversity of the natural environment and its current state, rather than just typological diversity.

The entropy measure of landscape diversity, expressed in bits, is illustrated on the map (Fig. 2B) and highlights areas of increased diversity that could be the focus of special nature management and recreational regimes. The region of Belokurikha stands out as having the highest diversity, particularly in the south and southeast, where a combination of mountain and mountain-valley landscapes covered by mixed forests dominated by conifers are present. To the west and southwest, granite cliffs that hang over precipices are surrounded by pine, fir, and larch trees. The presence of wildflowers and shrub trees, such as bird cherry, mountain ash, and rhododendron, on mountain slopes, as well as bizarre-shaped granite rocks on mountain tops and meadow-steppe vegetation with mountain taiga forests in river valleys, create an aesthetically pleasing environment that contributes greatly to the comfort and relaxation of visitors. This area provides a favorable background for visitors to enjoy maximum comfort and relaxation.

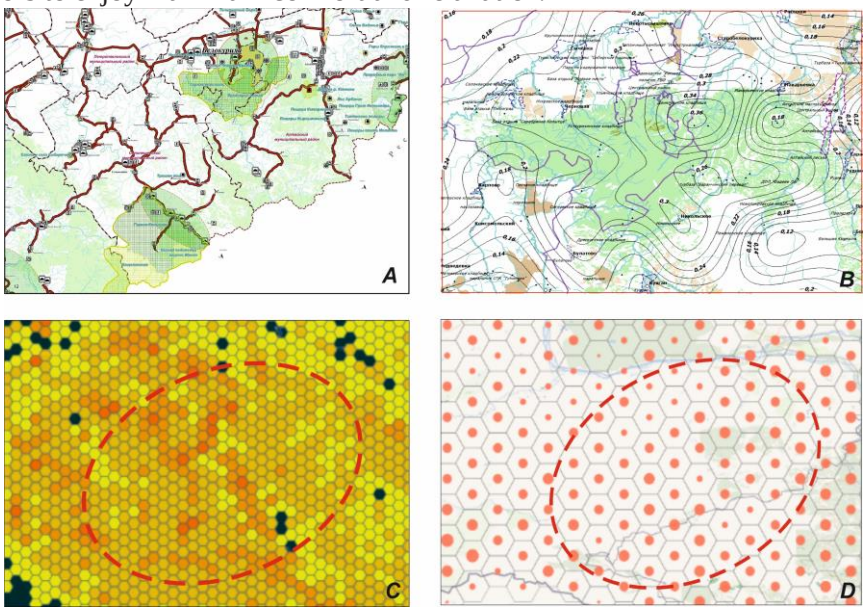


Figure 2. Correlation scheme of landscape diversity patterns with an updated version of the territorial planning scheme for Altai Krai: A - a fragment of the map of major tourist areas of Altai Krai; B - map of entropy measure of landscape diversity; C - biodiversity cartogram*, D – biodiversity cartogram*

Notes: The dotted line shows the Bolshaya Belokurikha tourist design zone,

** – generated automatically in GBIF (Digital Portal on Biodiversity 2022). The highest biodiversity is shown in red and brown, respectively.*

To gain a comprehensive understanding of the landscape diversity in the study area, we supplemented our data with information from the Global Biodiversity System website, which provided access to the GBIF portal. This allowed us to view and analyze biodiversity materials based on factors such as the number of observations, automated computer-based processing, provided samples, citation level, preserved samples (availability), fossil and live specimens (Biodiversity Digital Portal 2022). To build the maps in GBIF, we generated queries (Figs 2C, 2D). The cartogram (Fig. 2D) illustrates the distribution of diversity in terms of the number of recorded species for Altai Krai and its neighboring regions. Bolshaya Belokurikha stands out with a much higher diversity indicator than the Altai average, owing to its popularity among scientists and tourists alike and its accessibility due to the natural park 'Altai Foothills'. However, compared to other adjacent territories, Bolshaya Belokurikha does not have many unique findings of the flora. The uniform distribution of all available species in the range of the cartogram (Fig. 2C) suggests moderately high diversity (areal and species), confirming high potential for attraction in the study area.

To obtain a more comprehensive assessment of the developed material, the authors conducted field studies of the territory in the summer of 2022 and analyzed the spatial information-cartographic model of landscape diversity. We found that feather meadow steppes (0.18-0.23), valleys of small rivers and streams with well-developed bottoms with forbgrass and sedge-cereal meadows (0.2-0.3), gently sloping slightly undulating and hilly slightly dissected foothill plains with forb-grass-feather grass meadow steppes (0.18-0.2), and hilly ridged dissected surfaces with forb-grass meadow step are characterized by a moderately high diversity index (Fig. 2B).

In Bolshaya Belokurikha, the highest landscape diversity (0.25-3.5) was registered in sites with medium sloping medium-dissected surfaces with forb-grass-meadow steppes and grass-forb steppe meadows, as well as in steep dissected surfaces of mostly southwestern and eastern exposure with shrubby-meadow steppes. River valleys with forb-grass and sedge-grass meadows also have high landscape diversity (0.15-0.25).

To identify promising tourist areas, a comprehensive assessment of the area's tourist and recreational potential is required, which involves analyzing the total recreational value of territorial complexes through various indicators related to landscape diversity and attractiveness. The method of assessing the aesthetic qualities of natural landscapes is one such method used to evaluate landscape attractiveness, which considers the scenic beauty of an area, including the terrain with geological features, vegetation cover, water body, alternation of open and closed spaces, view panoramas, and colorful diversity of landscapes.

Functional zoning of the whole territory and its components is required to ensure sustainable tourism development. Various techniques are used to evaluate landscape attractiveness, including expert evaluations based on objective criteria, quantification of aesthetic qualities of landscapes, and ranking methods based on individual recreational qualities of landscapes and their combination (Scotts, Drielsma 2003; Rathoure, Patel 2020; Watling et al. 2020). The cartographic form of visualization of landscape diversity patterns is also essential in territory analysis, which involves assessing the diversity of areal units of natural complexes, their

complexity, mosaicism, and discreteness (Guselnikov, Chervyakov 1988; Moilanen 2008).

Other methodological approaches and indicators, such as the *Macintosh* measure (Magurran, McGill 2011; Magurran 2013), are used to most fully and objectively reflect landscape diversity in information-cartographic and GIS-models. The *Macintosh* measure considers a community as a point in a multidimensional hyperspace with coordinates, and the Euclidean distance of the community from the coordinates origin is used as a measure of its diversity (Moffett, Sarkar 2006; Rosenberg 2013). Therefore, Bolshaya Belokurikha, with its unique diversity patterns and potential for attraction, is a promising tourist destination.

Conclusion

Through our implemented studies, we have developed and tested a method for assessing and modeling landscape diversity, which is crucial for tourism development in promising natural areas. Our proposed technique includes quantifying diversity at any surface point and its visualization using GIS-based methods, mathematical modeling, and cartographic techniques. These approaches enable spatial analysis and assessment of landscape attractiveness.

The landscape diversity of the mountain plain system in our study area and the Belokurikha resort has contributed to the development of our isolinear model. This model is recommended for studying functional zoning of the territory through subcomplex allocation, in line with the requirements of modern urban planning legislation. By implementing our approach, we can preserve the diversity of natural landscapes, such as Bolshaya Belokurikha, and ensure a sustainable flow of tourists who can enjoy and interact with the natural environment.

Our findings provide valuable insights into the importance of considering landscape diversity and biodiversity in tourism development, emphasizing the benefits of using modern methods and GIS models for assessment and planning. Overall, our approach contributes to a more comprehensive assessment of the potential of promising natural areas for sustainable tourism development.

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