Anthropogenic Load on Transboundary Geosystems of Altai: Current State and Trends

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Abstract. Transboundary areas of the Altai Republic are notable for great diversity and vulnerability of natural complexes. Residential landscapes have one of the highest levels of anthropogenic transformation among the geosystems of the transboundary territories of the Altai Republic. Vacationing people, whose number is increasing every year, also have a significant impact on the environment. We have determined the percentage ratio of residential areas to the landscape area of their location to estimate the residential load. As a major criterion for assessing the recreational load, we propose to use the number of bed spaces for seasonal and year-round recreation at campsites, campgrounds, and hotels. As another criterion reflecting the impact of recreationists on the natural-territorial complexes of the studied areas, we consider the density of the tourist route network to the square kilometer of the landscape. The study has shown that the residential load on the landscapes in the transboundary areas of the Altai Republic is relatively low. Intermountain valley landscapes are the most loaded (up to 4.5% of the landscape area). The human impact on the high-mountain and mid-mountain landscapes is insignificant.

1. Introduction

The transboundary regions of the Altai Republic are distinguished by a great diversity of natural complexes. The rugged topography with a few level areas determines the mosaic nature of the landscape sections characterized by a high differentiation of conditions in the area as well as in the altitudinal-zonal plan. The heterogeneity of the geosystems of the studied region is enhanced by the human factor, which influence is one of the key reasons for the modern transformation of landscapes.

In the geocological paradigm, the concept of the anthropogenic load is not formalized in a general way, which gives rise to a variety of methods for parameterizing this phenomenon [1–4]. Attention is mainly paid to the actualization of the most common types of economic activities in the territory of a certain region and the analysis of their impact on natural complexes. Important in this aspect is the availability of reliable information that allows for a correct evaluation of the relationships in the system of human and nature.

Residential landscapes, which are defined as anthropogenic landscapes of populated places: cities and villages with their buildings, streets, roads, gardens, parks, have one of the highest levels of anthropogenic transformation among geosystems [5].
Residential landscapes are interesting not only for a high degree of change and synanthropization of ecosystems but also the possibility of a clear delimitation of the areas affected by degradation. Modern means of remote sensing allow mapping the territories of settlements with high accuracy and comparing their areas with those of natural landscapes. Such a comparison can be considered a criterion of anthropogenic pressure on landscapes. It should be immediately noted that only the anthropogenic load produced by the resident population would adequately reflect this criterion. For regions characterized by a highly mobile population, the indicator of the residential load is only partially applicable since the population of settlements and surrounding landscapes can vary significantly in different time periods.

2. Objects, data and methods
The Altai Republic is a recreational region and attracts people wishing to relax from all over the Russian Federation. Not all vacationing people stop and spend time within settlements; the geography of movement of many of them is much wider. To a greater degree, people move along highways and tourist routes. The northern regions are subject to the greatest load, but a rather large number of vacationers also penetrate the transboundary regions of the republic, the Ust-Koks and Kosh-Agach districts (figure 1).

![Figure 1. Tourist flow through the regions of the Altai Republic (compiled according to [6]).](image)

The official registration of the number of vacationers is based on the reports of recreational enterprises as well as the automobile flow recorded by video cameras, which are installed by the traffic police on the main roads of the republic. However, the transition of the car registration system started in October 2013 by the traffic police throughout Russia led to an error in determining the geographic placement of arriving tourists. In this regard, it is necessary to introduce a correction factor, considering tourist flow.
We suggest using the number of bed spaces for seasonal and year-round recreation at campsites, campgrounds, and hotels as a criterion of the recreational load. As another criterion reflecting the effect of recreationists on the natural-territorial complexes of the studied areas, we consider the density of the tourist route network per square kilometer of the landscape. These indicators will clarify the estimate of the anthropogenic load calculated based on a comparison of the areas of residential and natural landscapes and give a more complete picture of the state of local natural complexes.

The analysis was based on the data from the Ministry of Economic Development and Tourism of the Altai Republic as well as the materials from the tourist websites: KatalogTurBaza.ru → Russia → Altai Republic, TurBaza.ru → Altai, sibalt.ru → gorny-altai-bazy-otdyha/vse-basy-otdyha, and some others.

As a cartographic foundation, we used the landscape map of Gorny Altai developed by D.V. Chernykh and G.S. Samoilova [7]. The delimitation of the contours of settlements was carried out based on high-resolution images from Ikonos, QuickBird, WorldView2, and GeoEye filming systems, available from maps.google.com and maps.yandex.ru services. Digitization on a scale of 1:8000 resulted in the creation of a layer of residential areas. Localization of the network of tourist routes and the formation of a corresponding layer was carried out based on the data from the tourist websites.

Mapping was carried out in the QGIS geographic information system. Spatial data integration was implemented with the help of overlay in QGIS followed by the processing of cartometric and statistical information in LibreOffice Calc.

The residential load was determined as a percentage ratio of the area of residential areas to the landscape area of a location. As an indicator of the recreational load, the number of bed spaces per square kilometer of the landscape was used. The route load was determined based on the density of the route network per kilometer of the landscape.

3. Results and discussion

From 2002 to 2018 in the Kosh-Agach district, the population increased from 17,353 to 19,188 people (by 10.6%), whereas in the Ust-Koksa district population decreased from 17,481 to 16,317 people (minus 6.7%) [8]. The reasons for the decrease in the population were low rates of natural growth accompanied by a negative migration balance. Due to the lack of prospects for the development and a depressed state of the economy, young people left the region. However, the outflow of the residential population in recent years began to be compensated by people coming for recreation from other regions.

The Ust-Koksa district is recreationally attractive: the highest peak of the Altai Mountains, Belukha (4509 m), is located here; the N.K. Roerich’s Museum operates in the village of Verkh-Uimon; there are the picturesque spurs of the Katun ridge abound in lakes. The active development of touristic enterprises and the construction of hotels, tourist camps, and campsites in the district resulted in a rapid increase in tourist flow, from 92 thousand visits per year in 2015 to 103 thousand in 2017 (12%). Some vacationers stop within settlements; the rest stay at nearby camping sites and guesthouses in the residential territory.

The greatest load within the Kosh-Agach district is experienced by the intermountain hollow undrained low-flowing landscapes (1.8%) and intermountain hollow steppe landscapes (0.5%); a part of those areas is occupied by a group of settlements surrounding the administrative center of the district, the village of Kosh-Agach (other villages are Mukhor-Tarkhata, Kokoria, Ortolyk, Telengit-Sortogoy, New Beltir, Tobeler, and Zhana-Aul). In general, the load can be characterized as low since makes up only a fraction of a per cent in the district (0.1%) (figure 2a).

In the Ust-Koksa district, the intermountain hollow steppe landscapes (4.5%) are subject to the greatest load, and the level of this load is nine times higher than in similar landscapes of the Kosh-Agach district. The load of the intermountain hollow forest-steppe landscapes (2.4%) and mountain valley landscapes (about 1.3%) is high. The residential territories are mainly distributed within the Uimon Valley where the intermountain hollow and mountain valley landscapes are most fully
represented. In general, the load in the Ust-Koksa district is low (0.3%), although it exceeds that in the Kosh-Agach district (figure 2b).

![Distribution of the residential load by landscape types in the (a) Kosh-Agach and (b) Ust-Koksa districts.](image)

**Figure 2.** Distribution of the residential load by landscape types in the (a) Kosh-Agach and (b) Ust-Koksa districts.

Compared to a residential pressure on the landscapes of the North Caucasus, the indicator for the southern regions of the Altai Republic can be described as low. For example, in Dagestan, it is 1.4% [9], and throughout the North Caucasus it makes up 3.6% [10]. It should be noted that the share of built-up territories in the most loaded landscapes of the Ust-Koksa district is comparable with the North Caucasus indicators and even exceeds those indicators in the landscapes of Dagestan, which illustrates a less uniform distribution of the residential load in the transboundary regions of the Altai Republic.
The largest number of holiday destinations and recreational sites in the Kosh-Agach district is located within the intermountain hollow steppe landscapes - 298, but there are only 94 year-round recreational sites. The intermountain hollow undrained low-flowing landscapes have a comparable density of recreation places, 262 seasonal and 210 year-round ones (Figure 3a).

**Figure 3.** Distribution of recreational sites by landscape types in the Kosh-Agach (a) and Ust-Kokska (b) districts

In the Ust-Kokska district, the largest number of recreation sites is concentrated in the mountain valley flowing landscapes, which are periodically drained, 1433 sites (72% of the total number of recreational sites) (Figure 3b). The total number and density of recreational sites in the Ust-Kokska district are more than two times higher than those in the Kosh-Agach district. This indicator is
consistent with the total volume of tourist visits to these areas. The ratio of the number of visits to the Ust-Koks and Kosh-Agach districts in 2015 and 2016 differed by 2.5 times.

The most developed network of tourist routes was in the mountain valley landscapes due to better traffic roadways, the availability of water resources, and less rugged terrain. Despite higher visitation in the Ust-Koks and Kosh-Agach districts, the length of the route network here is lower than in the Kosh-Agach district. On the one hand, this indicates a lesser recreational load on local landscapes, and on the other hand, the flow density of vacationers in Ust-Koks is higher and the intensity of visitor impact on nature within the route network is much higher than in the Kosh-Agach district.

4. Conclusion
Thus, the residential load on the landscapes in the transboundary regions of the Altai Republic is relatively low and less than that in the North Caucasus region. The most loaded regions (up to 4.5% of the landscape area) are intermountain hollow landscapes. The largest number of recreational places is located in the intermountain hollow landscapes (Kosh-Agach district) and mountain valley landscapes (Ust-Koks district). The tourist route network has the greatest density within the mountain valley landscapes. The greatest human impact on the transboundary regions of the Altai Republic is affected by intermountain hollow and mountain valley landscapes. The human impact on the high and mid-mountain landscapes is insignificant.

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References
[1] Isachenko A G 2004 Theory and Methodology of Geographical Science (Moscow: Publishing Center Academy) p 400
[2] Milkov F N 1978 Man-Made Landscapes (Moscow: Mysl') p 86
[3] Nizovtsev V A 2007 On the History of the Formation of Modern Anthropogenic Landscape Science General and Applied Cenology 3 32-7
[4] Puchkin A V 2007 Mapping of Anthropogenic Changes in Landscapes Geography and Nature Resources 4 130-4
[5] Milkov F N 1973 Man and Landscapes: Essays on Anthropogenic Landscape Science (Moscow: Mysl') p 224
[6] Information on the Development of the Tourism Industry of the Altai Republic 2015 Income accessed online on 21st May 2018 via https://altai-republic.ru ›Tourism› development
[7] Chernyh D V and Samoilova G S 2011 Landscapes of Altai (Altai Republic and Altai Territory) Map M-1: 500000 (Novosibirsk: FSUE Novosibirsk Cartographic Factory)
[8] The Population of the Russian Federation by Municipalities 2018 Income accessed online on 10th September 2018 via https://www.gks.ru/folder/11110/document/13282
[9] Abdulaev K A 2009 Assessment of the Degree of Residential Load on the Landscapes of Mountainous Dagestan Izvestiya DGPU Natural and Exact Sciences 1 84-6
[10] Ataev Z V, Bratkov V V, Zaurbekov Sh Sh, Astapov M B and Mamonov A A 2012 Residential Load on the Landscapes of the North Caucasus South of Russia: Ecology, Development 4 100-7