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The problems of recreational territories of Pre-Olkhon area and Olkhon island

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Abstract. This paper contains the studies of the basic processes of degradation of geosystems on two key plots, exactly, Pre-Olkhon area and Olkhon island under conditions of recreational impact. As a result of observing this territory the assessment of terrestrial vertebrate diversity has been determined, the rate of degradation processes has been established and statistical dependence between parameters of geosystems and intensity of degradation has been found. Basing on the conducted researches it was revealed that the recreational territory of Pre-Olkhon area and Olkhon island has a high degree of degradation (IV-Vth stages of digression). The most difficult situation takes place on the coast of the Small Sea and on the island of Olkhon. The safe level of recreational load in this area without special arrangement of the territory should not exceed 1 person/ha.

1. Introduction

The problems of condition and protection of lake Baikal – since 1996 the site of world natural heritage, touch upon and concern not only local residents. At the same time, there is currently no system for monitoring the state of the coastal landscapes of lake Baikal. The outcomes of this research – the basis for maintaining an independent system of ecological monitoring of lake Baikal shore. As an object of the study the places with the highest recreational load were selected (Pre-Olkhon area and Olkhon island). Systematic observation for the processes of geosystems degradation enables to make up scientifically based forecasts of possible extreme situation (the loss of valuable natural objects, ravines, sheddings etc.). The data of recreational load and the intensity of degradation processes allow to estimate and predict the losses of recreational potential of the territory, give grounds for the regulation of recreational flows.

The goal of the research – to study the diversity of processes and the extent of degradation of Pre-Olkhon coastal and Olkhon island geosystems under conditions of recreational impact.

The tasks of the research are as follows:

1. The fulfillment of experimental studies and observations for main processes of geosystems degradation on two key plots: denudation (water erosion and deflation), compaction and destruction of soil cover, change and simplification of the species composition of vegetation, the decrease in the projective cover of woody and herbaceous vegetation.
2. The assessment of terrestrial vertebrate diversity: amphibians, reptiles, birds, small mammals on habitats of different types.



3. Determination of the rate of degradation processes in geosystems of various type under conditions of recreational impact. Defining statistical dependencies between the parameters of geosystems and the intensity of degradation.

2. Materials and methods

For determining crucial loads and connected with them processes of geosystems degradation – denudation (water erosion and deflation), compaction and destruction of soil cover, change and simplification of the species composition of vegetation, the decrease in the projective cover of woody and herbaceous vegetation – the natural observations were made at 38 test sites on the key plots of the research (figure 1) and office processing of the collected data.

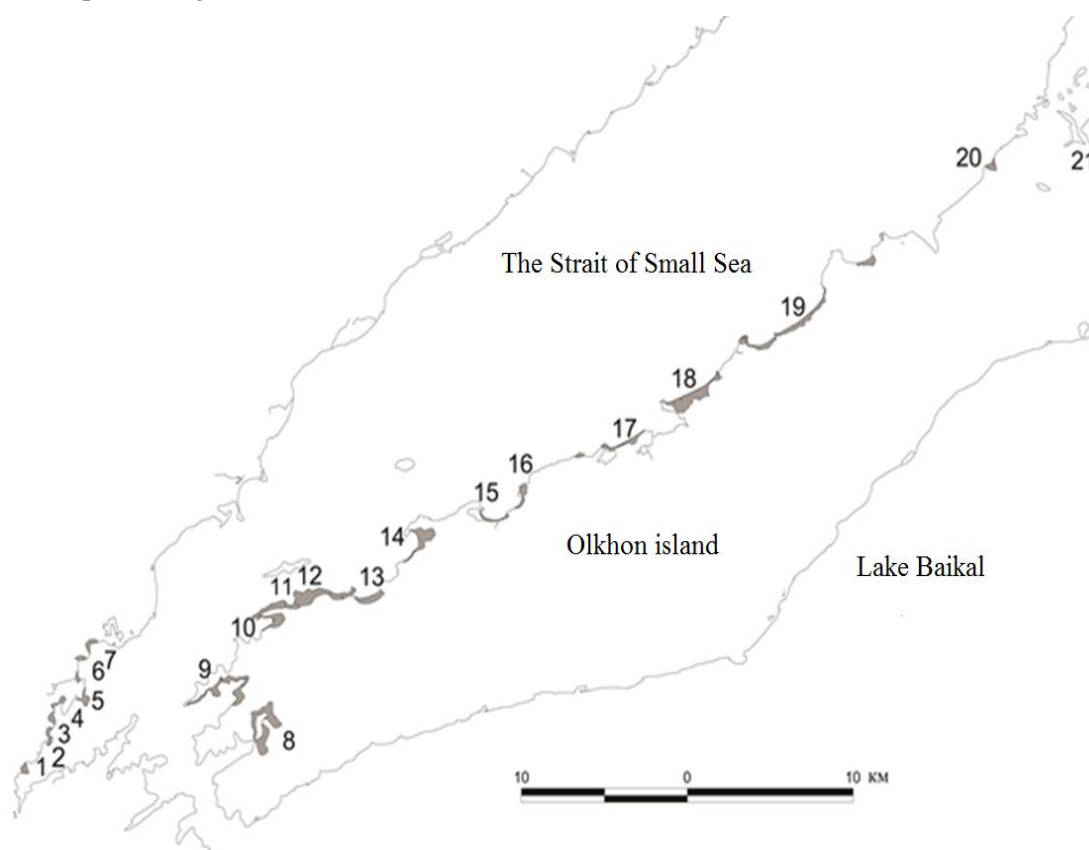


Figure 1. The location of the key plots of the research: A. Pre-Olkhon area: 1 – cape Halurinsky, 2 - cape Sharakshura, 3 - bay Lazurnaya, 4 - bay Shida, 5 - cape Ulirba, 6 - bay Khuzhir -Nuga (1), 7 - bay Khuzhir - Nuga (2); B. Olkhon island: 8 - lake Nurskoe, 9 - gulf Khul, 10 - gulf Bol. Khargoy, 11 - gulf Mal. Khargoy, 12 - cape Shara-Shulun, 13 - gulf Semisosenskaya guba, 14 - gulf Shebetsky, 15 - gulf Khankhoiskaya guba, 16 - gulf Toguy, 17 - beach Khuzhir, 18 - gulf Saraisky, 19 - gulf Bayan-Shungen, 20 - gulf Sasa, 21 - gulf Khaga-Yaman.

Complex descriptions (topography, soil and vegetation characteristics) and quantitative experimental measurements were made at test sites (10 x 10 m) which were put in different locations on the territories exposed to recreational impact. Then on the base of the elaborated criteria (table 1) the stages of recreational digression were determined.

The extent of vegetation cover destruction was determined on the base of analysis of describing floristic composition on the tiers and the data of projective cover and the height of each plant species, abundance, the nature of distribution and so on. Also, the reserve of phytomass in woody and grassy vegetation was assessed. The harvest of aboveground phytomass of the herbage is carried out by means

of cutting on the plots of size 0.5 x 0.5 m. in laboratory conditions the samples were dried out to an air-dry state and weighed.

Table 1. Criteria for determining a stage of recreational digression.

Indicator	Stages of recreational digression				
	1	2	3	4	5
Floristic composition	Initial	Changed to 5-10%, the least resistant species fall out	Changed to 10-20%, the change of edifiers	Changed to 50%	Totally changed, small number of species
Number of ruderal and resistant to trampling plant species	-	5-10% ruderal	10-20% ruderal and species resistant to trampling predominate	50% ruderal and species resistant to trampling predominate	More than 80% ruderal and species resistant to trampling predominate
Projective vegetation cover	Primary, characteristic of the aboriginal state	Reduced in comparison to primary	Increase due to ruderal and species resistant to trampling	30-40% (uneven, mosaic)	Less than 20%
Average height of herbage	Initial	Initial	Initial	Up to 5 cm	-
Area trampled (car-worn out) to the mineral horizon of the surface to the total area of the observed area %	Up to 1%	Up to 5 %	Up to 10 %	Up to 25 %	More than 25%
The share of path network	Up to 0,05	Up to 0,2	Up to 0,3	Up to 0,4	0,5 and more
The presence of trash and bonfire sites	-	Singularly	Singularly	Bonfire sites, the presence of trash	Plots and bonfire sites cluttered with trash

In the zones of intensive recreational impact on the key plot in Pre-Olkhon area (trails, tent camps, etc.), with different distances from the water's edge, the test sites of size 0.5 m x 0.5 m were allocated. At these sites determined: above- and underground reserve of phytomass (g/m^2); the average height of each plant species (m); projective cover of each plant species (%); litter and turf capacity (cm). As a result of the descriptions of soil cuts at the test sites and laboratory processing of soil samples were identified: the thickness of the soil horizons (cm) [1], their mechanical composition; volume weight (density) of soil (g/cm^3).

3. The outcomes of the research in Pre-Olkhon area and Olkhon island

Olkhon island. Here such steppes are spread as small bunchgrass and forb-tipchak steppes in combination to low forb and sagebrush lithophile as well as with halophytic-meadow ones in relief depressions; pine forests are rare-standing psammophyte, pine grass steppized and larch-pine forests. The locations mostly attractive for tourists are: gulf Saraisky, cape Khoboy, gulf Toguy, gulf Khankhoiskaya guba, cape Tashkay, cape Elguy, bay Khuzhir, cape Burkhan, surroundings of v. Kharantsy, surroundings of v. Peschanaya, gulf Khaga-Yaman and other sites.

The cape Khoboy is annually visited by more than 10 000 persons, and the number of visitors is steadily growing. This territory is a habitat of three-leaved oxytrope (*Oxytropis triphylla* (Pall.) Pers.), pebble feather grass (*Stipa glareosa* P.A. Smirn.), Popov poppy (*Papaver popovii* Sipliv) (narrow-local endemic of coasts and islands of lake Baikal), shore onions (*Allium altaicum* Pallas) and a number of

other narrowly-spread species of petrophyte rocky steppes, such as a tragacanth oxytrope (*Oxytropis tragacanthoides* Fisch.), Olkhon vetch (*Vicia olchonensis* (Peschkova) O.D. Nikif.). The steep Northern slopes of the cape serve as a refugium for highland species being relict here: a holly oxytrope (*Oxytropis oxyphylloides* Popov) included in the Red Book of Irkutsk region, a mountain lloydia (*Lloydia serotina* (L.) Reichenb.), a dotted saxifrage (*Saxifraga punctata* L.), a Sayan eritrichium (*Eritrichium sajanense* (Malyshev) Sipl.), a Kaufman milk vetch (*Astragalus kaufmannii* Kryl.). On capes there are large populations of birds nesting in rocks – a rock pigeon (*Columba rupestris* Pallas), a Daurian jackdaw (*Corvus dauuricus* Pall), a Siberian swift (*Apus pacificus* (Latham)), as well as the nesting sites of red-breasted mergansers (*Mergus serrator* Linnaeus) and goosanders (*Mergus merganser* L.).

As a result of the increasing number of vacationers in limited places of the coast, the area of trampled (up to the mineral horizon of the soil) territory is growing. The vegetation and upper soil horizon is subjected both to a direct mechanical effect (movement of vehicles, walking of a large number of people) and to indirect impact through deterioration of chemical and physical properties of the soil. The change in soil cover is expressed in reducing the fertile layer, mineral components of the soil and increasing its density [2].

On the whole, low projective cover of grassy cover (on the average 20 %), the average height of herbage 10-15 cm, the abundance of plants with wide ecological amplitude (hard sedge (*Carex duriuscula* C. A. Mey), narrow-leaved meadow-grass (*Poa angustifolia* L.), stemless cinquefoil (*Potentilla acaulis* L)) and the prevalence of cereal-motley grass associations are typical for this area. With increasing recreational impact, the herbage undergoes significant changes towards simplifying the structure and depletion of the species composition. According to the mechanical composition, the soil samples taken from the surroundings of cape Khoboy relate to light loam with rocky outcrops. The assessment of the structural state of the soil cover indicates low resistance of the soil cover to both water and wind erosion [3].

The gulf Saraisky near Khuzhir-village is known for its sandy beach which stretches for three kilometers between the cape Burkhan and the village of Kharantsy.

Uncontrolled growth of unorganized tourism in recent years has become one of the main factors of growth of anthropogenic load [4]. The flow of unorganized tourists to Baikal increases every year. Tourism has become the most powerful factor of anthropogenic impact on the nature of the Baikal shore. Such a strong impact more and more transforms the fragile natural complexes of the Baikal coast [5]. In the forests beside the beach the tent parking is equipped, but in summer period tents are located throughout the beach. It is here that there annually observed the largest concentration of tourists on Olkhon, which has a steady tendency to increase in the future due to the tourists from China. A large part of the number of "wild" tourists settle their "camps" at Saraisky beach, thousands of tourists staying in numerous hotels and guest houses of Khuzhir village come here to rest in summer. The excessive number of tourists in a small area has led to a number of negative consequences: the development of erosion processes, numerous roads, bonfires, decreasing area of projective cover of vegetation, the extinction of rare and endemic plant species, illegal loggings, violations of slopes during the installation of tents, the construction of tourist objects at the sites of unique natural landscapes [6].

Pre-Olkhon area. The greatest recreational load is towards the landscapes in areas of intensive rest (camping, recreation facilities, trails, roads). The coastal strip about 100 m wide is especially used.

The following types of landscapes at the level of facies groups are spread on the territory:

- Steep slopes rare-standing larch cereal-motley (*Agropyron distichum*, *Festuca lenensis*) in light sandy humus or gray humus strongly skeletal soils with rock outcrops.
- Steep slopes of mainly southern and south-eastern exposition rare-standing larch motley (*Antennaria dioica*, *Galium verum*)-wormwood (*Artemisia gmelinii*) and motley (*Scabiosa comosa*, *Potentilla longifolia*)-cereal (*Agropyron cristatum*, *Agropyron distichum*, *Festuca lenensis*) with a pea-shrub (*Caragana pygmaea*) in light sandy humus or gray humus strongly skeletal soils.

- Slopes of mostly northern and north-western exposition larch with a cotoneaster (*Cotoneaster melanocarpus*) sedge (*Carex pediformis*)-fescue (*Festuca valesiaca*)-motley grass (*Pulsatilla turczaninovii*) in light sandy humus or gray humus strongly skeletal soils.
- Saddles of rare-standing larch cereal-motley grass on arenosols.
- Near the peak and slopy motley-fescue (*Festuca valesiaca*) and low grass (*Eremogone meyeri*, *Chamaerhodos altaica*) sometimes with a pea-shrub (*Caragana pygmaea*) in light sandy little humus or gray humus strongly skeletal soils with rock outcrops.
- On the slopes of caragana cereal-forb (*Artemisia gmelinii*, *Aconogonon angustifolium*, *Phlojodicarpus sibiricus*)-sedge steppes in light sandy humus, little humus or gray humus strongly skeletal soils.
- Slope motley grass (*Thalictrum foetidum*, *Chamaerhodos altaica*)-fescue (*Festuca valesiaca*) steppes in light sandy humus or gray humus strongly skeletal soils.
- Slope motley grass (*Thalictrum foetidum*, *Pulsatilla turczaninovii*)-stipa (*Stipa baicalensis*) steppes in humus or little humus light sandy or gray humus strongly skeletal soils.
- Gentle slopes and intermountain depressions motley grass (*Cymbaria dahurica*)-cereal (*Agropyron cristatum*, *Stipa baicalensis*, *Festuca lenensis*) steppes in light sandy humus or gray humus strongly skeletal soils.
- Intermountain and lakeside depressions waterlogged motley grass (*Juncus salsuginosus*, *Equisetum variegatum*)-sedge (*Carex juncella*, *Carex pamirica*, *Carex melananthiformis*, *Carex enervis*) meadows in humic-gley soils.

In recent times the anthropogenic load on the landscapes of Olkhon area has been significantly increasing. The soil covers as one of the most important components of geosystem is subjected to intensive recreational impact in resting zone. As a result, at these sites the formation of road-path networks is taking place, trampling of ground vegetation at the locations of tent stays, compaction of soil cover, development of water erosion and deflation, reduction of the humus horizon depth and projective vegetation cover, worse water penetration and so on. The processes of plane and linear (gully) erosion (a group of slope water-erosion processes) are actively developing.

The mostly spread results of recreation activity promoting to erosion are the vegetation cover decreasing [7], the sanding of the surface soil layer and the destruction of humus-accumulated horizon, which connect to each other and are usually observed simultaneously. Thus, the reserves of overground phytomass of grassy vegetation of steppe and meadow types of facies range from 2.6 to 29.3 c/ha. In areas of dirt roads and tent camps the vegetation is absent in fact, and the reserve is reduced to zero. The lack of vegetation leads to the loss of humus, the destruction of soil structure [8]. The content of fine sand fraction in the upper horizon of 0-10 cm (more than 20 %) raises reaching 70 %.

As a result of the research the basic diagnostic indicators of digression in steppe and forest-steppe plant communities of Pre-Olkhon area have been revealed: the reduction of aboriginal species number, the rise in the number of trampling-resistant and inedible plant species (as pad digression overlaps), as well as annual species, total decrease in the projective cover of grassy vegetation and its uneven distribution (spotting on the parking places or bonfires, trails), soil compaction. In the forests there also observed thinning or disappearance of underwood, compaction or disappearance of the forest floor, physical damage to trees.

4. Conclusions

The assessment of geosystems state has shown a high degree of their degradation on most of touristic territories (IV-Vth stages of digression). The most crucial situation has taken place on the shore of the Small Sea and on the island of Olkhon. At the same time, accounting largely seasonal nature of functioning accommodation facilities, the main tourist press in these areas falls on three summer months with a peak in the period from June 20 to August 20. In the remaining nine months of the year, the restoration processes cannot fully compensate for the occurred violations of vegetation and soil cover.

On most territories of the Small Sea shore where touristic activity has concentrated the recreational digression higher than the third (III) stage is marked. The transitional synanthropic (III) phase is observed only on the leveled surfaces with sufficient or slightly excessive humidification (in the bottoms of falls and in the coastal zone) grown by meadow vegetation. Alongside this, the recovery capacity of secondary meadow communities is high.

The landscape of Olkhon island despite the whole apparent similarity to the landscapes of the Small Sea bays proved to be less resistant (2 per./ha, basing on available data selection). Psammophilic communities of the island (tract Peschanaya, Saraisky and Khuzhir beaches) are less resistant to recreational loads. A critical component is loose sands which hold thanks to growing plants in it. Even a small impact triggers the destruction of soil-vegetation cover. A characteristic feature is the transition from I-IInd stages of digression to IV-Vth, bypassing the synanthropic phase (stage III). The results of calculations enable to say that the safe level of recreational load without special arrangement of the territory should not exceed 1 person/ha.

As a result of the data obtained, we can say that:

- highly resistant landscapes – rocks and stone placers with a rare forest stand;
- low-resistant landscapes - places of spreading arenosols (sands) and landscapes of the steppe complex.

Currently, for the coastal areas of the studied territories the degradation processes, in the majority, exceeded the rate of recovery processes.

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