

Geosystem approach for assessment of soil erosion in Priol'khonie steppe (Siberia)

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Abstract. This research follows traditions of landscape science developed in Russia since the early XXth century which is considered the complexity of landscapes with their abiotic and biotic characteristics. As a study area, we choose *Piol'khon* plateau where the impact on the landscapes has significantly increased. The specific climate and soil conditions lead to soil erosion processes (downwash, rainwash and linear erosion) in the study area. On the rate of water erosion, are influenced follow factors: a stage of degradation (combination of species composition and trampling characteristics), steepness of slope, above-ground herbaceous phytomass, and amount of fine sand in the upper soil horizon. Most sensitive geosystems types to erosion processes were specified.

1. Introduction

Landscape science in Russia is a powerful driver for landscape differentiation with a strong focus on a physical environment. It is included theories of landscape genesis, landscape units, landscape hierarchy and others. The geosystem concept appeared in the 1960s when Viktor Sochava [1] introduced this term into geographical landscape research. Today, the term “geosystem” is widely used and define landscape units of all scales where natural components (air, water, flora, fauna, soil, basement rock) interrelate as a system and as an entirety react on the environment and human being. Geosystem approach is encompassing the complexity of landscapes with their abiotic and biotic characteristics [2].

In particular, the geographical context and landscape character can be very important for erosion regulation function. This provides significant perspectives for the application of geosystem-based concepts in ecological planning to avoid over-utilization and degradation of landscapes. By using landscape maps and land use maps the vulnerability to soil erosion can be mapped.

The aim of this investigation is the estimation of different landscapes' ability to mitigate silt and sand detaching by water erosion.

2. Situation and Natural Conditions

The study area (20 km²) is located on the western shore of Lake Baikal (Kurkutskiy bay) in the northern part of the *Piol'khon* plateau (Figure 1). From the one side the landscape structure of the study area is influenced by Primorsky Range, serving as an orographic barrier to the movement of air masses from the west, and from the other by the water mass of Lake Baikal. The annual rainfall is 200-300 mm, which is the minimum for Lake Baikal and most of them fall as the heavy rains. The geosystems of the study area are presented a large variety of steppes and forest steppes. Steppes, which cover 75,3 % of the area, are mainly rocky, occurring on gentle slopes with *Festuca* spp. and *Poa* spp.



or with *Agropyron cristatum* L., *Koeleria cristata* L., *Galium verum* L. and *Stipa baicalensis* Roshev. Forest-steppe and larch forest on the slopes cover about 24,7% of the study area. These geosystems are differing in the form of relief, soil types, vegetation species composition and degree of anthropogenic impact. These differences influence on the intensity of erosion in the different type of steppe and forest-steppe identified in the study area.

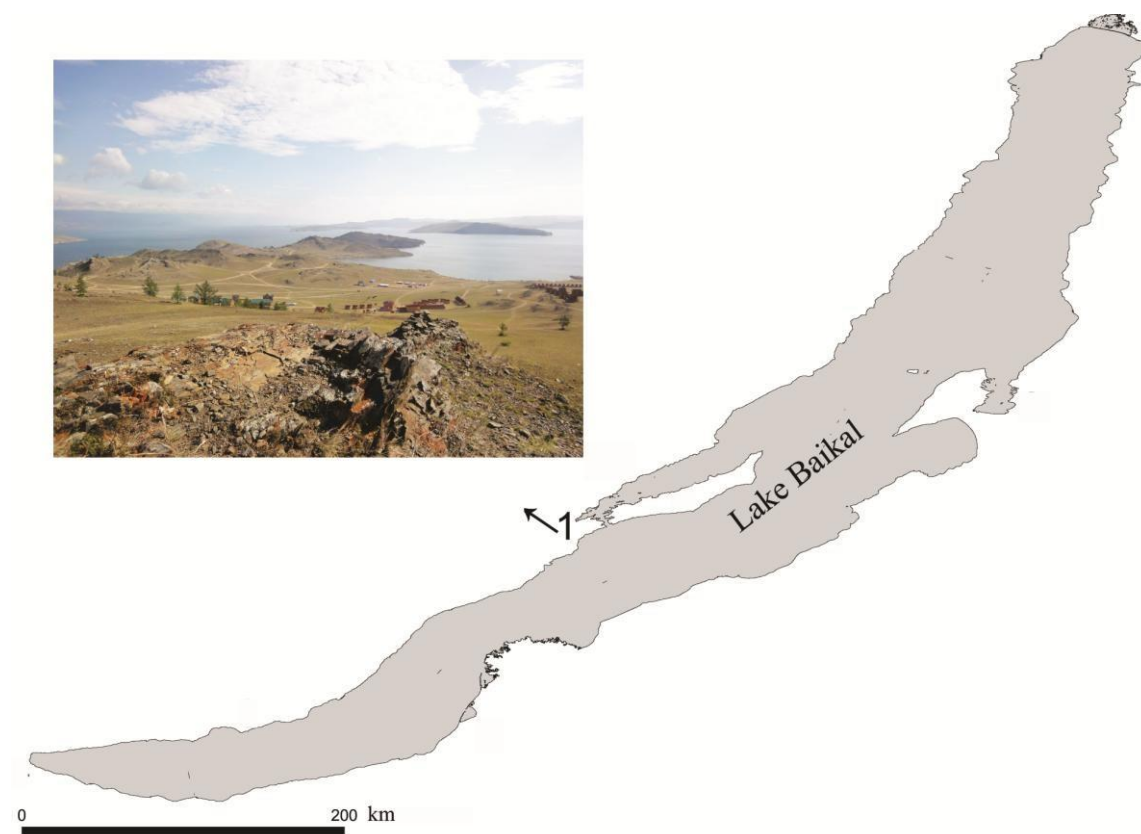


Figure 1. Scheme of Lake Baikal with location ("1") of study area on *Piol'khon* plateau

The *Piol'khon* plateau is characterized by a low-mountainous and low-contrast comb-and-dip relief with elevations of up to 800-900 m. The maximum depth of the erosion cut here is 200 m. The surface is complicated by ridges, hills, linearly extended brows, suffusion cavity, karst valleys and monadnocks [3]. Low-water and dry valleys with slopes dismember the territory, on a system of isolated shallow basins and isometric elevations. The bottoms of the depressions are composed of marbles, the ridges are made of gneisses and amphibolites. A distinctive feature of the elements of the relief is straightness, subordination to the general structure of the zone of dynamic influence of the Primorsky fault. On the described territory are narrow elongated ridges, brows, hills.

In the study area, various exogenous geomorphic processes are widespread, including potential hazards for human life. The group of permafrost processes is represented by thermokarst, frost heaving in negative landform, desertion on slopes. The group of gravitational processes is represented by landslides and debris fall, confined to steep rocky ridges, and to the ridge crests.

A group of subterranean processes of denudation of soluble and insoluble rocks is represented by karst and suffosia. Suffosion processes are confined to the foothills of ridges, spurs, places of underground water emergence.

The group of phytogenic sedimentation is the formation of peat bogs and bogging. Wetlands are found in the valleys, the bottoms of the lake basins. Groups of fluvial processes of erosion and accumulation of rivers and ephemeral streams. River erosion and accumulation are linear in nature, in

this area their activity is negligible. Group of aeolian processes, in particular, deflation and corrasion, are widespread everywhere, while accumulative ones are distributed locally.

The thin soil cover of the territory is fragmentary and has following features: coarse textured and the variety of petrographic composition, very gritty consistency, a light soil structure (sabulous and sandy loam with prevalent of the fine sand fraction), low humus content, poor soil conditioning and water stability. The soil is dispersal and has unstable water-air properties. Nonpercolative regime, which was formed under the influence of local climatic conditions and soil-forming processes, is typical for soils of study area [4]. Since they are well drained and formed with a small amount of precipitation, they are exposed to erosion processes under certain conditions.

Recently, the impact on the landscapes of Priol'khonie has significantly increased. The development of tourism, still unorganized, is typical for banks of Baikal. About 120 thousand tourists during the summer season visit this coast. All steppe valleys and slopes are covered by a dense network of unprompted auto-road. As a result the processes of downwash, rainwash and linear erosion are actively, developing-planar and linear (gully) erosion (a group of sloping water-erosion processes) (Figure 2). They were distributed on the slopes of small ridges and linearly extended manes, as well as along the road network.



Figure 2. One of gully in the study area

3. Methods and results

The geosystem map (scale 1:25 000) compiled by Zagorskaya [5] and was update with taking into account the expansion of dwellings, recreation facilities, roads (Figure 3).

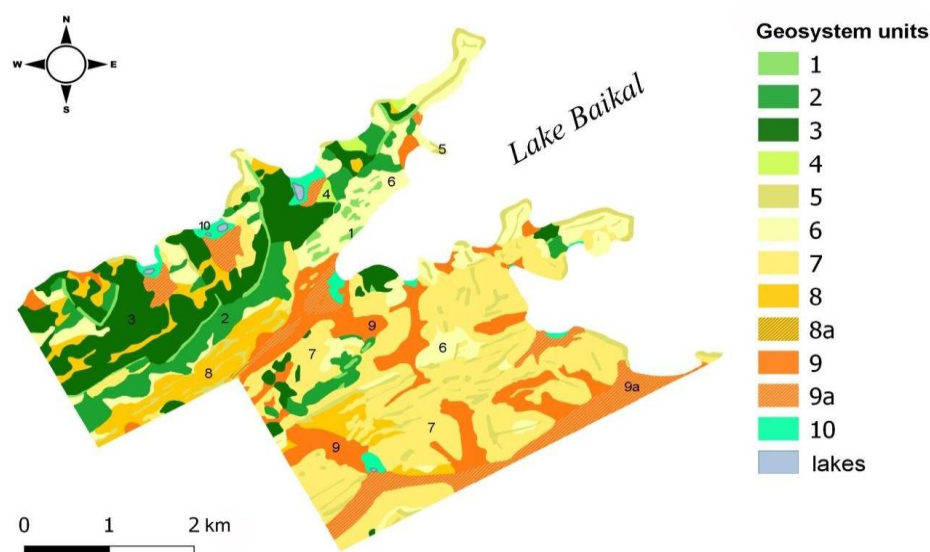


Figure 3. Geosystem map of the study area Geosystem units:

1. Understocked forest with *Larix sibirica* with *Agropyron distichum*, *Festuca lenensis* on Lithic Leptosols or Dystric Hyperskeletal Leptosols with rock outcrops on steep slopes.
2. Understocked forest with *Larix sibirica* with *Caragana pygmaea*, *Antennaria dioica*, *Galium verum*, *Artemisia gmelinii* on Lithic Leptosols or Dystric Hyperskeletal Leptosols on the steep slopes.
3. Steppified forest with *Larix sibirica* with *Cotoneaster melanocarpus*, *Carex pediformis*, *Pulsatilla turczaninowii* on Lithic Leptosols or Dystric Hyperskeletal Leptosols on the slopes.
4. Understocked forest with *Larix sibirica* forb-gramineae on Lithic Leptosols on saddles.
5. Steppe with *Festuca lenensis*, *Eremogone meyeri*, *Chamaerhodos altaica* in some cases with *Caragana pygmaea* on Lithic Leptosols or Dystric Hyperskeletal Leptosols with rock outcrops on ridge-tops and slopes.
6. Steppe with *Caragana pygmaea*, *Phlojodicarpus sibiricus* on Lithic Leptosols or Dystric Hyperskeletal Leptosols on the slopes.
7. Steppe with *Thalictrum foetidum*, *Chamaerhodos altaica*, *Festuca lenensis* on Lithic Leptosols or Dystric Hyperskeletal Leptosols on the slopes.
8. Steppe with *Thalictrum foetidum*, *Pulsatilla turczaninowii*, *Stipa baicalensis* on Lithic Leptosols or Dystric Hyperskeletal Leptosols on the slopes.
9. Steppe with *Cymbaria dahurica*, *Agropyron cristatum*, *Stipa baicalensis*, *Festuca lenensis* on Lithic Leptosols or Dystric Hyperskeletal Leptosols on the mild slopes and intermountains. 9a – Antropogenic modification with *Artemisia spp.* and *Potentilla spp.*
10. Marshy meadow with *Juncus salsuginosus*, *Equisetum variegatum*, *Carex juncella*, *Carex pamirica*, *Carex melananthiformis*, *Carex enervis* on Umbric Gleysols in the intermountains and depression.

During the fieldwork 55 study sites (10 x 10 m) were tested, which characterized different steppe and forest-steppe units. On each study sites, its characteristics were collected (Table 1). For the study sites on the slopes, a soil matter transfer by rainfall was measured with using a portable rainfall simulator [6]. According to these data, on the rate of water erosion are influenced follow factors: the stage of degradation (combination of species composition and trampling characteristics), steepness of slope, vegetation cover and above-ground herbaceous phytomass, amount of fine sand in the upper soil

horizon. The regression model with the coefficient of determination $R^2 = 0,74$ was calculated. Received data were interpolated within the boundaries of geosystem units with consideration of degradation stage and steepness of slopes (Figure 4).

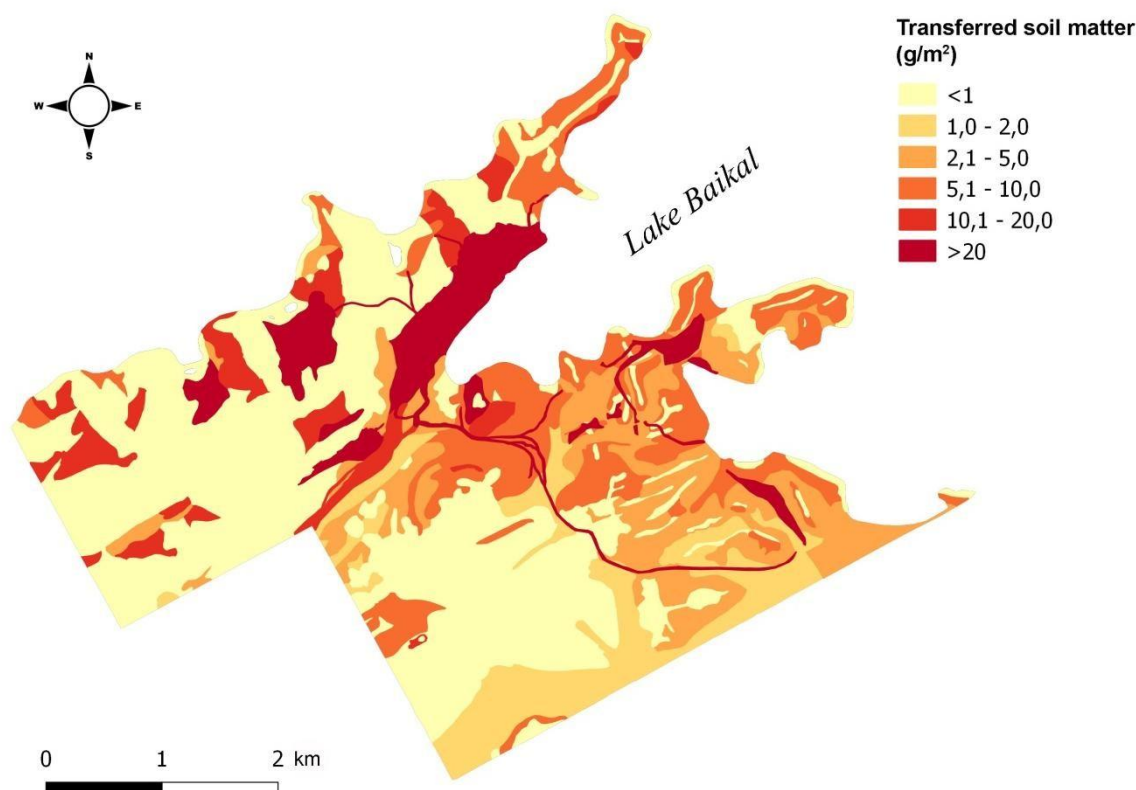


Figure 4. Exposure of the geosystems to water erosion processes

Table 1. Fragment of Data base of the fieldwork

Study sites	Steepness of slopes (angle degree)	Vegetation cover (%)	Degradation stage	Fraction of fine sand (0,25–0,05 mm) in the upper soil horizon (%)	Above-ground herbaceous phytomass (quintal/ha)	Organic carbon, %	Fraction (> 1mm) in the upper soil horizon (%)	Transfer of soil matter (g/m ²)
1	1,8	30	3	23,58	161,6	4,80	5,3	1,3
2	6,3	20	3	24,17	169,2	3,59	5,2	3,5
3	5,2	20	3	23,16	228,6	2,33	20,5	0,1
4	11,1	10	2	74,36	94,8	3,08	57,7	0,8
5	23,4	20	1	69,95	127,2	8,52	23,1	0,4

The results of experimental measurements of water erosion shown that the values of soil matter transfer varied from 0,01 to 52,4 g/m². The maximum values correspond to areas on slopes (7° and more) with low vegetation cover (0-20%) and disturbed upper soil horizon due to intensive human impact. The loss of vegetation leads to the loss of humus and destroying soil structure. The content of fine sand in the upper horizon of soil (0-10 cm) increasing and reach 70%.

4. Concluding remarks

Geosystem units differ in regulating potential of erosion processes and sustainability to impact. The following geosystems and they modifications are more exposure to water erosion processes:

- Understocked forest with *Larix sibirica* forb-gramineae on Lithic Leptosols on saddles.
- Steppe with *Caragana pygmaea*, *Phlojodicarpus sibiricus* on Lithic Leptosols or Dystric Hyperskeletal Leptosols on the slopes.
- Steppe with *Thalictrum foetidum*, *Chamaerhodos altaica*, *Festuca lenensis* on Lithic Leptosols or Dystric Hyperskeletal Leptosols on the slopes.

Type of geosystem unit on the local scale reflects the pattern of a combination of relief, soils and plant associations. Its areas on the map are the basis for interpolation of experimentally obtained values of water erosion.

Acknowledgments

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