Landscape structure of the Iya river basin

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Abstract. The article deals the landscape structure of the Iya river basin (left tributary of the Oka river). Landscape analysis was conducted in order to identify landscape-hydrological conditions of flood formation in 2019. Since the available small-scale landscape maps for the study area did not meet the requirement of the scientific issue in detail, a landscape map was compiled at a scale of 1: 500 000. The territory is heterogeneous in its physical and geographical conditions and topographic and humidification features, which resulted in formation of different landscapes and different types of intralandscape differentiation. We used a standard set of data to create the landscape map of the Iya river basin at a scale of 1: 500 000: electronic multi-scale topographic maps, Landsat 7 and 8 satellite images, digital terrain model, slope steepness and exposure maps, small-scale landscape, geobotanical and soil maps. We based on the landscape classification, which was developed for the map "Landscapes of the South of Eastern Siberia". The landscape diversity of the basin is represented by 39 groups of facies, united in 17 geoms and 4 classes of geoms. The landscapes of the mountainous, foothill-plain and upland-plain parts of the Iya River basin are substantially different in their appearance, characteristics of individual components, and their nature. The area of landscape units increases from southwest to northeast as the absolute height and vertical dissection of the relief decrease, their diversity increases towards the foothill part of the Iya river basin.

1. Introduction

The landscape analysis of the Iya river basin was conducted in order to identify the landscape-hydrological conditions of flood formation in the summer of 2019. The available small-scale landscape maps [1-3] did not meet the requirement of the assigned tasks in detail. Therefore, a landscape map of the Iya river basin was compiled at a scale of 1: 500000.

The Iya river basin occupies a part of the northeastern macroslope of the Eastern Sayan (northwestern part of the Peredovoi Range) and the plain areas in the northwest of the Irkutsk-Cheremkhovo plain. The absolute heights vary from 500 to 2462 m (Mount Ured-Ender). The climate in the upper part of the basin is excessively humid, with cold summers and moderately severe snowy winters; the middle and lower parts of the basin are optimally humid, with moderately warm summers and moderately severe dry winters [2]. The area under consideration is heterogeneous in its physical and geographical conditions. It can be conditionally divided into three parts, and each has its own conditions for landscape formation.

The first part is a mountainous area – upper part of the basin. It occupies part of the northeastern macroslope of the Eastern Sayan. Mid-mountainous relief with average absolute heights of 1200-1700 m above sea level and slopes 15-30° in the upper part and 10-15° in the lower part, with a
depth of more than 400 m. Overmoistening (average annual precipitation rates are 600-700 mm/year) [3]. Tundra soddy, organogenic-gravelly and podburs soils [2, 4].

The second part is a submountainous-plain (middle part of the basin). It occupies the southwestern part of the territory of the Presyan downwarp within the Iya river basin, the relief is flat with absolute heights of 500-600 m and slopes of 1-3°, dissection depth less than 100 m, sufficient moisture and precipitation up to 400-500 mm/year. Its prominent nature is the boggy territory and permafrost. Soils are soddy podzolic, soddy forest, and marsh and meadow in waterlogged areas.

The thirst part are elevated plains (lower part of the basin). It occupies the northeastern part of the Presyan downwarp within the Iya river basin. The sag-and-swell relief with deeply cut valleys (dissection depth 200-300 m) with absolute heights of 600-700 m, slopes of 5-10° prevail, moderate moisture, precipitation – 300-400 mm/year. Gray forest, soddy-podzolic, soddy forest and soddy-calcareous soils prevail.

According to the scheme of physical and geographical zoning [5], the territory of the Iya river basin belongs to two regions and five provinces – the Central Siberian taiga-plateau region (Central Angara southern taiga province) and the South Siberian taiga mountainous (Upper Priangarskaya bog-steppe-subtaiga piedmont, East Sayan mountain-mountain taiga mountainous, Oka mountain-taiga-mountainous province). The heterogeneity of physical and geographical conditions resulted in formation of different landscapes and different types of intralandscape differentiation. As a result of the analysis of landscape-forming factors the map “Landscapes of the Iya River Basin” was created.

2. Models and methods
We used electronic topographic maps of various scales, Landsat 7 and 8 satellite images, a digital elevation model, slope steepness and exposure maps, small-scale landscape, geobotanical and soil maps [1-3, 5] for creation of a landscape map of the Iya river basin at a scale of 1:500000. The landscape classification, developed for the map "Landscapes of the South of Eastern Siberia" [1], is taken as a basis. We preserved the legend structure and the main typological units. The main landscape types are represented in it by groups of facies, united in geomes and classes of geoms [7-9]. In the legend the facies groups are united in geomes according to altitudinal belts and development conditions (optimal, reduced, and limited), mesorelief and vegetation features. The titles of geom classes reflect the regional affiliation of the geoms.

The boundaries of landscape sections were drawn using the expert-visual method based on the above-mentioned satellite images (the main features were the colour and texture of satellite images) with slope steepness and exposure maps constructed using a digital elevation model. According to space images 2017-2019 recent burnt areas and post-fire small-leaved modifications of original landscapes were identified. The same methodological approaches were used to create a landscape map of the Central Ecological Zone of Lake Baikal for the purpose of determining recreational sustainability [10].

3. Results and discussion
Two types of natural environment are combined on the territory of the Iya river basin: tundra and taiga. Diverse landscapes are presented: goletz, subgoletz, mountain taiga, taiga and subtaiga. The regional landscapes are represented by Baikal-Dzhugdzhur, East Sayan, South Siberian and Central Siberian varieties. The landscapes of the mountainous, foothill-plain and upland-plain parts of the Iya river basin are substantially different in their appearance, characteristics of individual components, and their nature. The area of landscape units increases from southwest to northeast as the absolute height and vertical dissection of the relief decrease. At the same time, their diversity increases towards the foothill part of the Iya river basin. The typological diversity of the basin is represented by 39 groups of facies, united into 17 geoms and 4 classes of geoms. We designed the systematic list of facies groups for the Iya basin.

Goletz (mountain tundra) and subgoletz Baikal-Dzhugdzhur and East Sayan. Goletz alpine type: 1 – rocky and landslide-talus slope with a sparse vegetation cover. Goletz tundra: 2 – lichen altiplains; 3
– talus with lichen cover. Undergoletz shrub: 4 – plane surface and gentle slopes yernik-lichen; 5 – slopes with thickets of willows and tall grass swales; 6 – trough bottoms with shrub in combination with meadow tundra; 7 – slope of gravitational drift of Siberian dwarf pine-duschekia forest with larch sparse forests. Undergoletz larch-sparse forest and stone birch: 8 – plane sparse woody surface of Siberian stone pine, fir and spruce; 9 – slope Siberian stone pine alder-yernik moss-lichen.

Mountain taiga Baikal-Dzhugdzhur. Mountain taiga larch trees of reduced development: 10 – slopes of sheet erosion, sparse stands with mixed undergrowth lichen. Mountainous larch of reduces development: 11 – slopes with Siberian stone pine and mixed undergrowth. Submountain subtaiga larch: 12 – bottoms of depressions (with Siberian larch and admixture of pine) forb.

Mountain taiga South Siberian. Mountain taiga dark conifers of reduced development: 13 – gentle-slope Siberian stone pine alpine rhododendron subshrub-true moss with bergenia; 14 – slope Siberian stone pine with larch, mostly with bergenia; 15 – flat surfaces with Siberian stone pine and fir subshrub-small-grass-true moss; 15а – post-fire modifications with birch and aspen. Mountain taiga dark conifers of limited development: 16 – slope fir- Siberian stone pine blueberry-grass-true moss, in places with bergenia; 16а – post-fire modifications with birch and aspen; 17 – slope Siberian stone pine with spruce and larch, subshrub-true moss; 18 – piedmont uplands fir- Siberian stone pine subshrub-small grass (with tall grasses)-true moss. Piedmont and intermountain depressions taiga dark conifers of limited development: 19 – moraine and piedmont uplands Siberian stone pine with spruce and larch cowberry-true moss; 19а – post-fire modifications with birch and aspen (including cutover areas); 19b – post-fire modifications (recent burns); 20 – valley spruce and Siberian stone pine with larch mixed-shrub grass-true moss. Piedmont and intermountain depressions taiga Siberian stone pine larch of limited development: 21 – valley grass and grass-moss bogs with spruce, Siberian stone pine and larch. Mountain taiga dark conifers of optimal development: 22 – slope Siberian stone pine-fir blueberry-true moss; 23 – grass-moss slopes with fir and spruce. Piedmont and intermountain depressions taiga dark conifers of optimal development: 24 – piedmont plains of spruce and Siberian stone pine-fir-grass; 24а – post-fire modifications with birch and aspen (including cutover areas); 25 – piedmont plains fir-Siberian stone pine moss-grass; 26 – valley spruce and larch-spruce grass-subshrubs. Mountain taiga pine: 27 – slopes of uplands with larch, subshrub-grass with alder undergrowth; 27а – anthropogenic modifications with birch and aspen; 27b – post-fire modifications (recent burns); 28 – slopes of low mountains and uplands with an admixture of larch, grass-cowberry; 28а – anthropogenic modifications with birch and aspen (including burns and cutover areas). Submountain subtaiga pine: 29 – plain with undergrowth of Rhododendron dauricum; 29а – anthropogenic modifications with birch and aspen; 30 – plain and depression bottoms cowberry-fors with shrub undergrowth; 30а – anthropogenic modifications with birch and aspen; 30b – anthropogenic modifications after fires and felling; 31 – indelta marsh with subshrub-sedge-moss cover in combination with sedge meadows and pine forests; 32 – valley cowberry-grass; 32а – anthropogenic modifications with birch and aspen; 32b – anthropogenic modifications after fires (recent burns); 33 – valley cowberry-grass; 34 – valley meadows of forb-grass and grass-sedge in combination with willows and swamps.

Plain-plateau Central Siberian. Southern taiga dark coniferous uplands: 35 – flat surfaces spruce-Siberian stone pine-fir blueberry-grass (with small grasses)-true moss; 36 – slope Siberian stone pine-fir, sometimes with larch, small-grass-true moss. Southern taiga dark conifers (on plains): 37 – valley spruce (with larch and pine) grass and grass-moss. Pine forest plains and valleys of oligotrophic-xeromesophytic regime: 38 – piedmont plains and depression bottoms of cowberry-bearberry or lichen; 38а – anthropogenic modifications with birch and aspen; 38b – anthropogenic modifications after fires (recent burns).

Subtaiga (on elevated plains and plateaus) larch and pine: 39 – flat surfaces pine grass; 39а -anthropogenic modifications with birch and aspen.

Anthropogenic objects: 40 – arable land and fallow lands; 41 – ponds; 42 – coal cuts; 43 – waste heaps and dumps; 44 – urban-type settlements; 45 – rural-type settlements.
Goletz, subgoletz (rocky talus, moss-lichen tundra, alpine-type meadows and subgoletz dark conifer woodlands), mountain taiga (dark and light conifer) and intermountain depressions taiga landscapes are common in the mountainous part of the territory. In the upper part of the middle mountains (at altitudes above 1000 m), goletz alpine-type and tundra landscapes prevail: predominantly rocky and landslide-talus slopes with sparse vegetation cover, lichen altiplain, slope talus with lichen cover (No. 1-3; hereinafter in the text - groups of facies according to the systematic list). They are combined with slopes of sheet erosion sparse larch with mixed undergrowth lichen (No. 10) and slope larch with Siberian stone pine and mixed undergrowth of limited development (No. 11). A distinctive feature of the landscape structure of this part of the Iya river basin is the abundance of steep-slope landscapes with sparse vegetation, a small area of sections and their frequent recurrence, low diversity and high contrast.

In the lower part of the middle mountains (at altitudes of 800-1000 m), mountain taiga dark conifer landscapes of limited development prevail in area: slope fir-Siberian stone pine blueberry-grass-true moss, in places with bergenia (No. 16), slope Siberian stone pine with spruce and larch subshrub-true moss (No. 17) (occupy slopes of different steepness, including the lower parts of slopes to river valleys); and subalpine shrub and sparse forest landscapes: plane surface and gentle slopes yernik-lichen (No. 4), slope of gravitational drift of Siberian dwarf pine-duschekia with sparse larch forests (No. 7) and slope Siberian stone pine alder-yernik moos-lichen (No. 9) in frequency of occurrence.

In the foothill-plain part of the territory (at altitudes of 600-800 m), foothill and intermountain depressions taiga, foothill subtaiga, southern taiga uplands and plains, subtaiga (on elevated plains and plateaus) landscapes are common. The gradual transition from mountain to plain of the basin is carried out through the landscapes: of the foothill uplands fir-Siberian stone pine subshrub-small-grass (with tall grass)-true moss (No. 18), moraine and foothill uplands, Siberian stone pine with spruce and larch, cowberry-true moss (No. 19).

The submountain part of the basin is characterized by the predominance of landscapes of marsh indeltas with subshrub-sedge-moss cover in combination with sedge meadows and pine forests (No. 31). They are combined with plains and depression bottoms, pine cowberry-forb landscapes with shrub undergrowth (No. 30).

On the elevated plains in the northern part of the basin, southern taiga dark conifer uplands prevail. Namely – slope Siberian stone pine-fir, sometimes with larch, small grass-true moss (No. 36) in combination with submountain and on elevated plains and plateaus subtaiga landscapes – plain and depression bottoms with pine cowberry-forb with shrub undergrowth (No. 30) and flat surfaces pine grass (No. 39). Large areas are occupied by arable land and fallow lands (No. 40).

4. Conclusion

Due to significant geomorphological and climatic differences, goletz, subgoletz, mountain taiga, taiga, subtaiga landscapes are represented within the basin. From the southwest to the northeast, with the transition from the middle mountains to the foothill and elevated plains, there is a successive alternation of the prevailing landscapes: altiplain tundra-lichen and larch sparse forests with mixed undergrowth lichen in the middle mountains at heights of more than 1000 m, slope Siberian stone pine with spruce and larch subshrub-true moss (800-1000 m) and foothill uplands fir-Siberian stone pine subshrub-small grass (with tall grass) – true moss (600-800 m); marsh with shrub-sedge-moss cover in combination with sedge meadows on the foothill plains, as well as plains and depression bottoms pine cowberry-forb with shrub undergrowth (500-600 m); slope Siberian stone pine-fir, sometimes with larch, small-grass-true moss (600-700 m).

Differences in the landscape structure of the Iya river basin are predetermined by the heterogeneity of physical and geographical conditions. The landscapes of the mountainous, foothill-plain and upland-plain parts of the Iya river basin differ significantly in their appearance, characteristics of individual components, and the nature of their functioning. The landscape diversity of the basin is represented by 39 groups of facies, united in 17 geoms and 4 classes of geoms. The area of landscape
units increases from southwest to northeast as the absolute height and vertical dissection of the relief decrease; their diversity increases towards the foothill part of the Iya river basin.

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