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Spatial Structure of Mountain Forests of the Lake Baikal Southwestern Coast

Eugene G. Suvorov [α] & Natalia I. Novitskaya [σ]

Abstract- Spatial structure of mountain forests of the Baikal region is presented through geobotanical mapping. Correlated analysis of the vegetation cover structure and data of landscape investigations was done. The study area is characterized by a high natural diversity of plant communities with dominating forests reflecting the ecotopes differentiation in mountain conditions as well as by the contact of regional physical geographical structures and experiencing anthropogenic impacts. The map legend conveys the identified spectrum of forests diversity. Area is provided for the integrated stability areas of plant communities. Forest stability is regarded as ability of plant communities to retain their phytocenotic structure. An expert assessment of stability is made. This territory is notable for dominance of stable and moderately stable forest communities. The modern mosaic-dispersed distribution of communities of equifinal successional stages gives evidence of the current favorable conditions for preservation of dark coniferous forests.

Anthropogenic impacts are concentrated in the coast of the Lake Baikal dominated by areas of forest communities of stably long-lasting and short-lasting derivative stages of successional recovery. The lower mountain-taiga belt and adjacent submontane plains with tracts of Baikal's terraces are dominated by structures of weakly stable and unstable areas. Geosystem differentiation gives conditions for the occurrence of different forest communities as well as the spatial inhomogeneity of the stability areas in relation to primary and derivative structures in light of the existing kinds and intensity of anthropogenic impact.

Keywords: forests spatial structure; mapping; landscape structure; forests stability.

I. Introduction

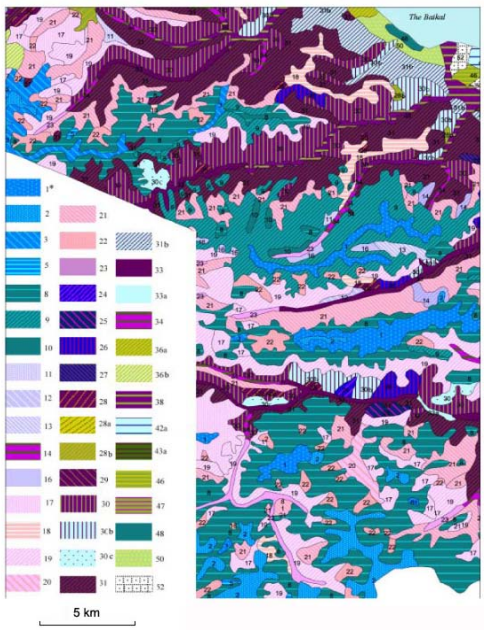
Studies of structural dynamic features, spatial organization of geosystems and environmental forming and environmental retention role of vegetation in the territory next to the Lake Baikal are conducted for the purpose of nature management policy developing of the Baikal natural territory, priority of which are the actions, directed toward the maintenance of geosystems in the natural state of functioning, providing conditions for unique natural water resource forming. The complicated geological engineering conditions of this area require the realization of approaches of rational mountain nature management in such place.

The study of the natural conditions differentiation and their determining processes in the south of Baikal is conducted according to the thematic directions, which cover different nature components, and also by complex physical geography, which investigates variety, regional specific character and dynamics of natural complexes or geosystems. One of the fundamental directions of such studies–spatial presentation of territory differentiation, based on the mapping results.

In this article on the basis of the expert evaluation of the sustainability of plant communities and mapping of the contemporary geosystem states the attempt to assess bearings of their territorial stability was made. Case study is executed basing on the example of the territory of the south Baikal.

II. Methodical Approaches

Regularities of forests communities distribution within the case study area are reflected on that carried out map by the authors of the contemporary state of the vegetation of the Slyudyanka region in 1:400 000 scale, that represent the existing variety and the state of plant communities taking into account their primary and derived structures (Novitskaya and Suvorov 2012). Map material for this paper was worked out with ArcView 3.2a programme. We gave the fragment of the investigated section (Fig. 1).



* *Taxon numbers are in Legend*

Fig.1: Fragment of the map "Contemporary state of the vegetation of the southwestern Baikal region"

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For mapping we used the materials of ours field research routes for the different years with complex physical geographical descriptions, the results of aero- and space photograph deciphering, and extrapolating data of large-scale mapping of several key plots, materials of reginal forest survey, and also the analysis of the existing literary sources, too (Epova 1960a, 1960b; Medvedev 1986; Molozhnikov 1986).

Representation of ecotopic structure for this map was based on the differentiation of the topographical structure and the assessment of the contemporary dynamic state of geosystems and it was connected with the carrying out the maps of the physical geographical chorological and landscape typological differentiation of geosystem structure in the south of Baikal (Suvorov and Titaev 1999; Suvorov 2002, 2012) according to properties of the facies (large scale geosystem unit) structure of this territory and taking into account its generalization with mapping on different scales.

As a whole the legend of geobotanical map transfers the variety of the region forest communities and reflects the genetic structure and dynamic principles of typification and construction of the plant communities classification (Sochava 1979). The characteristic of the primary lands of taxons contains fundamental fitosociology characteristic and information on conditions of locality, their dynamic states (the latter were designated by literal indices).

Legend to the map

"Contemporary state of the vegetation of the southwestern Baikal region"

Vegetation
High mountain vegetation
Mountain tundras

The South- Siberian formations

1. Unclosed groups (*Saussurea pricei* (Konspekt…2005), *Tephroseris turczaninovii*, *Smelowskia bifurkata*) of the nival denudation and alpine type relief forms.
2. Mosses (*Aulacomnium turgidum*, *Dicranum elongatum*)-lichen (*Cetraria cuculata*) tundras with sections of dryad (*Dryas oxyodonta*) and meadow tundras of the flattened surfaces and gently slopes.
3. Bergenia (*Bergenia crassifolia*)-bilberry (*Vaccinium myrtillus*)-phyllodoce (*Phyllodoce caerulea*) with *Rhododendron adamsii* lichen of summit moor lands and of gently slopes.
4. Willow (*Salix glauca*, *S. sajanensis*)-ernik (*Betula rotundifolia*) communities of flattened surfaces.
5. Ernik (*Betula rotundifolia*)-willow (*Salix saxatilis*) communities in combination with subalpine meadows of gently slopes and catchment lows.
6. Sedge (*Carex bigelowii subsp. ensifolia*) and cotton-grass (*Eriophorum sp.*) communities of the swampy lows.

Alpinotype meadows

The South- Siberian formations

7. Alpinotype *(Aquilegia glandulosa, Trollius sajanensis)* and subalpinotype *(Geranium albiflorum, Saussurea latifolia)* meadows, brushwood thickets *(Betula rotundifolia, Salix glauca, Duschekia fruticosa).*

Taiga (boreal) vegetation
Subgoletz sparse woods and brushwood thickets
Bering phratry of formations
Baikal -Dzhugdzhur formations
Mountain pine thickets (Pinus pumila)

8. Mountain pine with *Rhododendron aureum* lichen-mosses communities of the flattened surfaces and slopes.
9. Mountain pine with *Vaccinium vitis-idaea* communities of steep slopes.
10. Mountain pine with *Rhododendron aureum* true mosses communities with sections of the subalpine meadows of trough valleys.

Ural-Siberian phratry of formations
South-Siberian formations

Dark coniferous sparse woods
Firry forests (Abies sibirica)

11. Firry subshrub (*Vaccinium myrtillus*, *Empetrum nigrum*, *Vaccinium vitis-idaea*, *Rhododendron adamsii*)-lichen-true mosses with sections of subalpine meadows sparse woods of watersheds and slopes.
12. Firry subshrub (*Vaccinium myrtillus*, *Vaccinium vitis-idaea*)-true mosses sparse woods in combination with grassy, subshrub-forb fir mountain parks and with multiple-forb meadows of flattened surfaces and southern gently slopes.
13. Firry bergenia-cowberry (*Vaccinium vitis-idaea*)-forb sparse woods of steep southern slopes.
14. Firry with with a touch of spruce and Siberian Stone pine with mountain pine subshrub (*Ledum palustre*, *Vaccinium vitis idaea*)-bergenia-true mosses sparse woods of steep northern slopes.
15. Firry and spruce-fir with Siberian Stone pine and mountain pine and with *Rhododendron aureum* subshrub (*Ledum palustre*, *Vaccinium myrtillus*, *Vaccinium vitis-idaea*)-true mosses sparse woods of northern gently slopes.
16. Firry subshrub (*Ledum palustre*, *Vaccinium vitis-idaea*)-grass with the sections of tall grass meadows sparse woods of trough valleys.

Siberian stone pine forests (*Pinus sibirica*)

17. Siberian stone pine ernik (*Betula rotundifolia*)-subshrub (*Ledum palustre*, *Vaccinium vitis-idaea*)-true mosses sparse woods of watersheds and slopes.
18. Siberian stone pine and fir-Siberian stone pine rhododendron (*Rhododendron aureum*)- subshrub

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(*Vaccinium myrtillus*, *Empetrum nigrum*, *Vaccinium of vitiы idaea*)-short grass-true mosses sparse woods of flattened surfaces and southern gently slopes.

19. Siberian stone pine and fir-Siberian stone pine subshrub-forb with bergenia true mosses sparse woods of southern steep slopes.
20. Siberian stone pine and fir-Siberian stone pine with larch and with mountain stone pine and *Rhododendron aureum* subshrub-true mosses sparse woods of northern gentle slopes.
21. Siberian stone pine and fir-Siberian Stone pine with larch with mountain pine subshrub (*Ledum palustre*, *Vaccinium vitis idaea*)-bergenia-true mosses sparse woods of northern steep slopes.
22. Siberian stone pine with mountain pine and *Rhododendron aureum* subshrub grassy sparse woods of trough valleys.
23. Siberian stone pine-spruce and spruce-Siberian stone pine with fir and larch with the spots of mountain pine shrub (*Ribes glabellum*, *Spiraea salicifolia*, *Lonicera pallasii*) grass-mosses sparse woods of mountain valley.

Mountain taiga forests

Firry forests (*Abies sibirica*)

24. Firry and spruce-fir cowberry-true mosses, bilberry-true mosses (*Pleurozium schreberi*, *Hylocomium splendens*) short grass (*Trientalis europaea*, *Maianthemum bifolium*)-large grass-small reed-forb forests of watersheds and gently sloping southern slopes.
25. Firry and fir-spruce with Siberian stone pine marsh tea (*Ledum palustre*)-subshrub short grass (*Trientalis europaea*, *Maianthemum bifolium*)-true mosses (*Pleurozium schreberi*, *Hylocomium splendens*), cowberry (*Vaccinium of vitis-idaea*)-true mosses with bog mosses (*Sphagnum sp.*) of gently sloping northern slopes.

    25a. Birch and aspen subshrub-grass derived communities.
26. Firry and Siberian stone pine-firry subshrub-true mosses with bergenia and cowberry-forb with bracken forests of steep southern slopes.

    26a. Pine-larch cowberry-grass derived communities.

    26b. Birch and aspen small reed-grass derived communities.
27. Siberian stone pine-fir with dushekiya (*Duschekia fruticosa*) subshrub (*Ledum palustre*, *Vaccinium myrtillus*, *V. vitis-idaea*) bergenia true mosses, cowberry-short grass (*Trientalis europaea*, *Maianthemum bifolium*, *Mitella nuda*)-true mosses forests of steep northern slopes.

    27a. Birch dushekia subshrub grassy with bergenia derived communities.

Siberian stone pine forests (*Pinus sibirica*)

28. Siberian stone pine, by places *Rhododendron aureum*, subshrub (*Vaccinium myrtillus*, *V. vitis-idaea*) short grass (*Trientalis europaea*, *Maianthemum bifolium*) polytric (*Politrichum commune*)-true mosses (*Pleurozium schreberi*, *Hylocomium splendens*) forests of watersheds and gently sloping southern slopes.

    28a. Larch-pine subshrub short grass-true mosses, pine-larch cowberry true mosses derived communities.

    28b. Pine-larch short grassy true mosses, forb-small reed derived communities.

    28c. Birch and aspen grassy derived communities.
29. Siberian stone pine with larch marsh tea-subshrub (*Vaccinium myrtillus*, *V. vitis-idaea*)-short grass(*Trientalis europaea*, *Maianthemum bifolium*, *Mitella of nuda*)- polytric-true mosses (*Pleurozium schreberi*, *Hylocomium splendens*) forests; great bilberry (*Vaccinium uliginosum*)-marsh tea true mosses with *Sphagnum sp*. forests of gently sloping northern slopes.

    29a. Larch with the pine cowberry short grassy true mosses; larch marsh tea sedge-bog mosses derived communities.

    29b. Aspen-birch with larch and pine cowberry forb-short grass-small reed, marsh tea sedge bog mosses derived communities.
30. Siberian stone pine cowberry with bergenia forests of the steep eroded southern slopes.

    30a. Larch with pine cowberry forb derived communities.

    30b. Birch marsh tea-forb derived communities.

    30c. Shrub-grass derived communities.
31. Siberian stone pine with larch dushekia (*Dusshekia fruticosa*) subshrub-marsh tea short grass (*Trientalis europaea*, *Maianthemum bifolium*, *Mitella of nuda*)-true mosses (*Pleurozium schreberi*, *Hylocomium splendens*) with bergenia forests of steep northern slopes.

    31a. Larch with pine dushekia cowberry-true mosses derived communities.

    31b. Birch dushekia short grass-moist grass with fern cowberry-short grass-true mosses; sedge-short grass derived communities.
32. Siberian stone pine with larch cowberry true mosses forests (*Pleurozium schreberi*, *Hylocomium splendens*); Siberian stone pine with larch cowberry short grass-true mosses forests; marsh tea short grass-true mosses forests of gently sloping northern slopes.

    32a. Larch and Siberian stone pine-larch with birch cowberry-forb and ccowberry-true mosses derived communities.

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32b. Birch and aspen cowberry-forb and cowberry-true mosses derived communities.

33. Spruce-Siberian stone pine with fir, larch, fragrant poplar (*Populus suaveolens*) dushekia- willow small reed (*Calamagrostis langsdorffii*)-large grass forests of valleys.
    33a. Birch with larch, Siberian stone pine, fir, fragrant poplar large grass-small reed derived communities.
    Spruce forests (*Picea obovata*)
34. Larch-spruce with Siberian stone pine forb-horse tail-small reed (*Calamagrostis langsdorffii*) brush-covered forests of mountain valleys.
35. Siberian stone pine-spruce with larch dushekia bushy forb-gramineous forests of well drained gully bottoms.
    35a. Birch dushekia forb-gramineous derived communities.
    Larch forests (*Larix sibirica*)
36. Siberian stone pine-spruce-larch forests of steep northern slopes with the presence of mountain pine in undergrowth.
    36a. Larch with Siberian stone pine and spruce with the presence of mountain pine derived communities.
    36b. Birch with Siberian stone pine and spruce with the presence of mountain pine derived communities.
37. Siberian stone pine-spruce-larch small birch (*Betula humilis*)-bushy (*Salix sp., Ribes glabellum*, *Spiraea salicifolia*, *Lonicera pallasii*) great bilberry-marsh tea sedge-bog mosses forests of wide swampy valley bottoms .
38. Larch with Siberian stone pine, spruce, fragrant poplar bushy large grassy-forb-small reed valley forests.
    38a. Birch and aspen-birch with poplar grass-small reed communities.
    Pine forests (Pinus sylvestris)
39. Pine and larch-pine rhododendron (*Rhododendron dauricum*) with spirea (*Spiraea media*) small reed-forb and bracken (*Pteridium pinetorum*).
40. Pine, larch-pine gramineous-forb and cowberry-forb forests with steppefication sections of steep southern slopes.
    40a. Birch gramineous-forb and cowberry-forb derived communities.

Swamps

41. Mesotrophic bogs and oligotrophic moors sedge-bog mosses with sparse tree layer (spruce, larch) at plateau.

Submontane depression communities
Forests
Dark coniferous

42. Fir-Siberian stone pine with spruce bilberry true mosses (*Pleurozium schreberi, Hylocomium splendens*) and bilberry short grass (*Trientalis europaea*, *Maianthemum bifolium, Mitella nuda, Oxalis of acetosella*)-true mosses submontane flat forests at low watersheds
    42a. Birch forb-bilberry derived communities.
43. Siberian stone pine-spruce with fir, larch and birch bilberry-cowberry-forb true mosses forests at mountain aprons within the slope lower parts.
    43a. Larch and Siberian stone pine-larch with birch cowberry-forb and cowberry-true mosses derived communities.
    43b. Birch cowberry-bilberry-forb derived communities.

Light coniferous forests (Larix sibirica, Pinus sylvestris)

44. Pine-larch and larch-pine cowberry-forb and gramineous-forb forests of gently sloping southern slopes.
    44a. Birch gramineous-forb derived communities.
45. Pine-larch and larch-pine rhododendron (*Rhododendron dauricum*) and forb-bracken forests with the sections of exposure steppes of the steep slopes of light aspects.
    45a. Birch grassy derived communities.
46. Larch and pine-larch gramineous-forb and cowberry-forb, by places derived birch forests, plain forests.
47. Spruce-larch bushy grass-mosses forests with sections of lowland sedge swamps and meadows at valleys.

Bushy brushwood

48. False subgolets brushwood of mountain pine with *Rhododendron aureum* sedge (*Carex macroura*)-short grass-lichen-mosses.
49. Willow-ernik (*Betula fruticosa*) with spirea (*Spiraea salicifolia*) forb mossy.

Meadows

50. Gramineous-forb with rarefied small-leaved forests and sedge eutrophic swamps of submontane plains.
    Swamps
51. Oligotrophic moors and mesotrophic bogs sedge-sphagnum and subshrub (*Ledum palustre*, Vaccinium uliginosum, *V. vitis idaea*, *Oxycoccus microcarpus*)-sedge-sphagnum with open woodland with Siberian stone pine, spruce, birches of submontane plains.

Anthropogenic formed areas

52. Ruderal and cultural communities of residential areas.
53. Agrocenosis.

III. Spatial Cenosis Structure

The complex spatial cenosis forests structure of the southwestern Baikal area is caused by the existing contrasting natural conditions, connected with

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the mountain nature of relief, by the Lake. Baikal influence, and it is complicated by anthropogenic impacts. Territory is characterized by the fold-block mountains, composed by the metamorphic rocks of Precambrian complex, and also by the contact of mountain morphostructures and basin of the Baikal Lake, whose tectonic development still continues. General regularities of spatial distribution are connected with altitudinal zonality, the exposition effects, the characteristics of local ekotopes, which determine the structure of biogeocenosis of the Khamar-Daban ridge, of the spurs of the Eastern Sayan and of the Olkhinskoe plateau. Two physical geographical oblasts were allocated here: Southern-Siberian mountain (A) and Baikal-Dzhugdzhur mountain taiga (B), within theirs landscape okrugs are represented by the specific spatial regional topological spectra (pattern) of geosystems (Fig. 2).

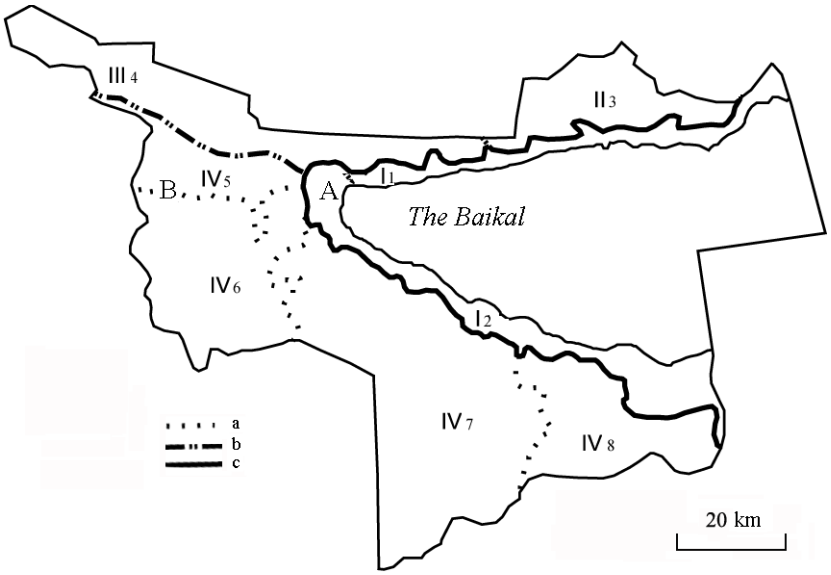


Fig. 2: Physical geographical subdivision of Slyudyanka administrative region

Physical geographical oblasts: A - Southern-Siberian mountain, B - Baikal-Dzhugdzhur. Provinces: I - Pribaikalskaya (Cis-Baikal) goletz-mountain taiga (subprovince of the Baikal lake basin), II - Verkhnepriangarskaya (the Angara upper reach) marshy with steppe formations and subtaiga submontane, III - Okinsko-Sayanskaya mountain taiga and goletz, IV - Dzhidinsko-Khamar-Dabanskaya mountain taiga and depression. Landscape okrugs: I1 — Southwestern coastal mountain taiga, I2 - South-Baikal taiga submontane-plain, II3 – Kitoi-Angara submontane-subtaiga, III4 - Onot-Taisuk middle mountain dark- and light- coniferous taiga, IV5 – Tunka depression steppe formation-subtaiga, IV6 - Zun-Murin goletz-mountain taiga, mountain taiga, IV7 – Utulik mountain taiga goletz, IV8 – Khara-Murin goletz-mountain taiga. Boundaries: a – landscape okrugs, b-provinces, c – physical geographical oblasts.

In the center of Eurasia almost predetermines climate with the cold winter and relatively warm moderate-moist summer. The action of middle latitudes air masses is manifested during the year. Mean January temperatures in the high mountain part –20.–25 of °C, July — 10–17 °C. In the coastal part because of the lake winter there is about 8–10 °C warmer than in the more remote regions, and it has cooler summer. Because of the orographical heterogeneity contrasts in the precipitation are observed. Their distribution is connected with the altitudinal zonation, and also with the local ridges arrangement, which intercept precipitations of the ruling of north western air mass transfer. If in the mountains at a height 1200–1500 m a.s.l. it falls out about 1500 mm, but on the coast of lake (455 m a.s.l.) — about 400 mm, and on the eastern, inverted to the Baikal slopes of Olkhinskoe plateau in the north-eastern part of the region — about 300 mm.

The Southern-Siberian mountainous oblast, which represented with three provinces of distinguished landscape structures, occupies major portion of the administrative region territory as area study. From them Dzhidinsko-Khamar-Dabanskaya mountain taiga and depression province (IV) has the greatest area. It is differentiated into four landscape regions (5–8), which are, in turn, characterized by the peculiar spatial mosaics of geos-systems and by the spectra of altitudinal zonation from high mountains (up to 2300 m) to lower mountain taiga belt (850–900 m). Here high mountain vegetation is represented with communities of

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alpinotype meadows and mountain tundras of the South-Siberian formations of Ural-Siberian phratry.

For the southern part of the research area with the alpine form of landscapes and with the active slope processes (tooth pointed crests of ridge-spurs, erosional and glacial forms)it is more characteristic the open fragmentary groups of grassy (Saussurea pricei, Tephroseris turczaninovii, Smelowskia bifurkata) plants. In the golets belt there are approximately at the same heights extended alpine tundras, predominantly lichen, with the small sections of short grassy alpine meadows and nival small meadows.

In the high mountain northern part of the territory (Zun-Murin golets-mountain taiga okrug) golets geosystems with flattening relief forms and gently slopes dominate. The surfaces of plateau are occupied with stony scatterings and alpine tundras: stony, stony-dryad, lichen, mosses-lichen, sedge-mosses. On the golets with the flattened surfaces and gently slopes there are extended mossy (*Aulacomnium turgidum*, *Dicranum elongatum*)- lichen (*Cetraria cuculata*) tundras with sections of dryad, grassy tundras and moors with the rarefied cover from bilberry (*Vaccinium myrtillus*), fillodotse (*Phyllodoce caerulea*), rhododendron of Adams (*Rhododendron adamsii*), bergenia (*Bergenia crassifolia*) and the lichens of the Stereocaulon. In the upper part of the southern slopes the small sections of desert type alpine meadows are noted with the dryad, rarely - kobresia moors.

The geosystems dynamics is connected also with the processes of bogging up and peat forming on the watershed depressions and on the solifluction slope terraces covered with sedge (*Carex bigelowii subsp. ensifolia*) and with cotton-grass (*Eriophorum sp.)* communities.

Along the slopes of water-collecting lows and the gently sloping sections of the blown snow-patches with mountain-medow soils there are formed the characteristic south-siberian subalpine luxuriant forb meadows (*Aquilegia glandulosa*, *Viola altaica*, *Campanula dasyantha*, *Diphasiastrum alpinum, Doronicum altaicum, Ciminalis grandiflora, Carex atterima, Pedicularis amoena, Hierochloe alpine, Geranium krylovii*).

Lower located subgolets sparse woods are characterized by the propagation of dark coniferous forests with fir tree (Abies sibirica) and Siberian stone pine (*Pinus sibirica*).

In the western part of the territory, within Zun-Murin golets-mountain-taiga landscape okrug (6), the subgolets belt was formed by sparse woods with Siberian stone pines and larches (*Larix sibirica*) having ground birch underbrush (Betula rotundifolia). The single plants of the larch dwarfish form are observed up to 2000 m height and more. At the same altitudal level as sparse woods and above there are some places of ground birch brushwood and, by places, especially on the southern slopes, — the brushwood of Adams's rhododendron. Subalpine and alpine meadows occupy insignificant areas.

At the forests border within subgolets belt there are extended fragmentary and compact mountain pine communities of Baikal-Dzhugdzhur formation of Bering phratry, which occupy predominantly the slopes of northern aspect. Mountain pines (*Pinus pumila*) form high density brushwood with height about 1,5 m and with single Siberian stone pine and fir. In the underbrush rhododendron golden (*Rhododendron aureum*), subshrub cover from bilberry, crowberry (*Empetrum nigrum*), cowberry (*Vaccinium vitis-idaea*), and Adams's rhododendron predominate. Grassy forms almost are absent, projective cover is about 5 %. They are encountered bergenia (*Bergenia crassifolia*), may-lily (*Maianthemum bifolium*), from characteristic alpine plants – alpine whitlow grass (*Draba alpine*). Mossy cover is near 80 % (Hylocomium splendens, Aulacomnium sp.). Peaty-gley soils with peat horizon about 10 sm. Soil profile depth reaches 45 cm, ferrugination is observed in the middle part of the profile, the skeletal nature of soil substratum is expressed. Thus, near The Grassy summit (1550 m) such complex is located within altitude range 1530–1550 m and has relatively small area. It is located on the northern slope of narrow watershed with about 35° steepness which has stony outcrops of gneisses. Subalpine meadows are noted at the same heights on the southern slope of the same watershed in the upper part of the water-collecting low.

Below, in the altitudes range from 1000–1050 to 1470–1500 m, it is characteristic the propagation of fir mountain park type woods, taking place of relatively gently sloping slope- watershed surfaces with inclination 7–10°. The mesorelief of such locations is nival-fluvial formed as a result of refreshing freezing-thawing processes influence throughout year and loose surface deposits. Mountain forest turf medium-loamy soils are developed on the eluvium of the carbonate rocks, but they are lixiviated. Their depth is about 0,5 m, it is expressed gumus soil profile, skeletal nature of profile increases from depth 0,2 m.

Arboreal layer consists from fir tree and Siberian stone pine (standing formula 8Fir2Pine), the height of trees is 6–8 m, diameter 20–25 cm, crowns cover - 0,2. The renewal of tree standing is not marked. Grassy cover is gramineous-forb (moist grassy) with projective cover 80–100 %. Wood millet (*Millium effusum*), small-reed (*Calamagrostis obtusata*), geranium (*Geranium sp.*), violet (*Viola uniflora*), Siberian globe flower (*Trollius sp.*), hellebore (*Veratrum lobelianum*) have great abundance. The groups of Siberian stone pine with cowberry-bergenia cover takes places with gneisses outcrops.

Major part of the entire area is occupied by slope geosystems of mountain taiga belt with South-

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Siberian communities where fir and Siberian stone pine dominate, and also their derived communities with larch, pine (*Pinus sylvestris*) and small-leaved species (*Betula platyphylla, Populus tremula*), extended to a height 1400–1450 m. They are bilberry, cowberry, short grasses (*Trientalis europaea*, *Maianthemum bifolium*), true mosses (*Pleurozium schreberi, Hylocomium splendens*) communities predominating. On the slopes of light exposure Siberian stone pine grassy forests prevail, on the shady — Siberian stone pine and fir with spruce (*Picea obovata*) marsh tea (*Ledum palustre*) true mosses.

For north-eastern, inverted to the Baikal macroslope of Khamar-Daban ridge it is characteristically significant propagation of fir tree, by places including shoots renewal, and it is typical the preserved relicts of the grassy plants of tertiary broad-leaved forests.

Composition of the forest communities of northern macroslope of Khamar-Daban ridge is differed by first of all the large presence of larch and the altitudinal shift of the boundary propagation of mountain taiga light coniferous forests. In this case the larch is extended to upper boundary of subgoletz belt. The lower mountain part of Zun-Murin landscape okrug is presented with larch forests: in common pine-larch small reed-forb communities which upwards are changed by cowberry-grass with the rhododendron dahurski (*Rhododendron dahuricum*), larch cowberry-marsh tea-mosses and Siberian stone pine-larch. And above Siberian stone pine subshrub-mosses forests grow.

Valley geosystems are ernik with riverside brushwood of willows, and also with sections of steppefication and swampy with carex-like kobresia (*Kobresia sp.)* meadows.

Mountain taiga communities of Southern-Siberian type occupy coming from the north outlying outspurs of Eastern Sayan with erosional-denudation low-mountain relief and heights of up to 1300 m and Olkhinskoe gently undulating plateau with height of up to 900 m (Okinsko-Sayanskaya province).

On the spurs of Eastern Sayan up to height about 900 m (the southern slopes to 1100 m) there predominate communities of light coniferous forests, which upward along the slope are replaced by dark coniferous mountain taiga, and else above they are changed by Siberian stone pine subgolets sparse woods. Here the watershed territories of flattened manes are represented with equifinal states of dark coniferous taiga with supremacy of Siberian stone pine communities - subshrub (*Vaccinium myrtillus, V. vitis-idaea*), short grass (*Trientalis europaea*, *Maianthemum bifolium*) politric-true mosses (*Pleurozium schreberi, Hylocomium splendens)*.

At dominating gentle slopes of Olkhinskoe platea (Verkhnepriangarie province) there are predominated recovered states of dark coniferous communities as light coniferous (*Larix sibirica, Pinus sylvestris*) and small-leaved rows of middle age and ripen with developing undergrowth of dark coniferous tree species (*Pinus sibirica, Abies sibirica, Picea obovata*), mainly Siberian stone pine, which have stable prolonged derived character (grassy, short grass-cowberry-true mosses and cowberry-marsh tea-politric-true mosses, at lower slope parts with sphagnum mosses). Distinctly there are manifested the exposure differences (north-south), expressed in variability properties of vegetation and soils.

The valleys of middle and upper reach of rivers, influent into the Baikal, are wide, planoconcave, bushy covered and frequently swamped. Bogging up in the planoconcave upper reaches of small rivers (actually this is interfluve) can bear mesotrophic or even oligotrophic nature as, for example, in the upper reaches of the Bolshaya Shumikhar-river, where in the plateau there is located sedge-sphagnous uneven raised bog with small pools swamp. The soils are peat and with longterm permafrost. Wood layer spare-stand is low-quality appraisal, with crowns cover of 0,1–0,2. It consists of larch, Siberian stone pine, spruce and birch with quantitative predominance of Siberian stone pine. In underbrush there are sweetbrier (*Rosa acicularis*), subshrub layer is great bilberry-marsh tea with cowberry and the large cranberry (*Oxycoccus microcarpus*). The mossy continuous cover consists on 60% of sphagnum mosses with impregnations of true and politric (*Polytrichum commune*, *Pleurozium shreberi, Ptilium crista-castrensis*) and lichens of *Cladonia* kind.

Submontane forests of the adjacent to the lake steep southern slopes and slopes of the intermediate exposure (Southwestern coast mountain taiga okrug) include pine with larch rhododendron (*Rhododendron ahuricum*), cowberry, forb-bracken with steppefication communities and with sections of exposure steppes. Area of steppe formations along the coastline slopes of the Baikal is elongated almost without breaks about 80 km with removal from the lake by places through the mountain river valleys by 2–4 km. At steep southern coast slopes with rocks outcrops steppe formations most probably has natural origin, caused by the activity of contemporary exogenous processes and by the absence of snow cover in winter. The sections of the steppe appearance have sedge-gramineous-forb in composition of grassy layer, wormwood -forb with chernozem-like soils, they contact within sloping gullies and depressions with meadow-forb cover, and also with pine and larch-pine forests of cowberry and forb with underbrush of dahurski rhododendron at more gently slopes.

The primary forest structure of this part of the Baikal coast is disrupted by fellings and forest fires, and inherent main background of contemporary vegetation composes of birch and aspen-birch forb forests. The

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slopes of different steepness near settlements are used for homestead sections and cattle pasturing. On the watersheds with the cut forests or on the bottoms of valleys there are located the small sections of haying land.

The fragment of mountain depression subtaiga landscape with steppe formations at slopes is represented within Bystrinskaya and Torskaya depressions, connecting Tunkinskaya and Baikal depression (Tunka depression steppe formed-subtaiga okrug). Climatic conditions here are more arid, that caused by depression location and isolation from the action of the advective processes, transferring moisture. Subtaiga light coniferous forests predominate, they are strongly disrupted and partially substituted by derived small-leaved communities. Submontane inclined plains of both depression sides are covered with larch and pine-larch small reed-forb forests. Also here at the slopes of southern aspect there are extended steppe formed-grass larch forests and fragments of real steppes. On sandy ouvals there are dry steppe formed pine forests with sparce grassy cover with black-berried cotoneaster (*Cotoneaste rmelanocarpus*), rhododendron daurski, Siberian pea-shrub (*Caragana arborescens*) in the underbrush. The fragments of spruce and poplar-spruce forests are encountered in the low floodlands, which alternate with the sections of meadows and brushwood of willows.

As a whole the variety of locations near the Baikal creates favorable environment for existence as for the most south-eastern center of developing of dark coniferous forests of Ural-Siberian phratry of formations (Sochava 1978), and for fragments of steppe formation, which have natural origin, and it also appears as a result of anthropogenic action.

Coastal area is subjected to the lake greatest impact. It is determined by zone of the direct climatic lake influence upon the surrounding territory. By places at flattened sections of the drained Baikal terraces were preserved dark-coniferous forests with primary structure -fir- Siberian stone pine with spruce bilberry true mosses (*Pleurozium schreberi, Hylocomium splendens*) and bilberry short grass (*Trientalis europaea, Maianthemum bifolium, Mitella nuda, Oxalis acetosella, Waldsteinia ternata*)-true mosses, and also prolonged-derived larch-Siberian stone pine communities. The short and prolonged-derived communities of a small-leaved (*Betula platyphylla*, *Populus tremula*) row are concentrated predominantly near the residential territories.

At the same time in the coastal zone there is noted the manifestation of false goletz belt with the vegetation elements of the Baikal-Dzhugdzhur formation in brushwood in the form of the local spots of mountain pine with golden rhododendron and bilberry lichen-mosses participation (withinin the South-Baikal taiga submontane-plain okrug).

In the flattened submontane plain at the foot of Khamar-Daban ridge there are extended oligotrophic swamps and mesotrophic bogs of sedge-sphagnum and subscrub (*Ledum palustre*, *Vaccinium uliginosum*, *V. vitis-idea, Oxycoccus microcarpus*)-sedge-sphagnum with open woods of Siberian stone pines, spruces, the birches, which, judging by the structure of the peat deposits and its botanical composition, were formed on the spot of large in the area shallow lakes (Novitskaya 1981).

In some locations of northeastern Khamar-Daban ridge macroslope as a result of specific mesoclimate there were created favorable conditions for some species retaining with particular kin connections and areas, which testify about the propagation in the past in this territory of the Baikal Siberia of coniferous-broad-leaved forests. The most of these species dwell in the dark coniferous (firry and Siberian stone-fir) forests and in the brushwood of the riverbed of the Bezymyannaya, the Utulik, the Babkha, the Solzan, the Langutay, the Khara-Murin, the Slyudyanka, the Snezhnaya, which characterized by increased humidity, rich soils, frequently with well manifested humus horizon. There are encountered male fern (*Dryopteris filix-mas*), enchanter's nightshade (*Circaea caulescens*), prominent (*Corydalis bracteata*), valdshteinia (*Waldsteinia ternate*), Baikal anemone (*Anemone baicalensis*), monkshood (*Aconitum sukaczevii*), dwarf bay (*Daphne mezereum*), wood falcebrome (*Brachypodium sylvaticum*), fescues (*Festuca altissima* and *F. extremiorientalis*), mountain bladderfern (*Oreopteris limbosperma*), Hancock's sedge (*Carex hancockiana*), fragrant bedstraws (*Galium odoratum*) and small bedstraw (*G. triflorum*), lady's slippers (*Cypripedium calceolus*, *C. guttatum*, *C.* macranthon). In the high mountain belt within the subalpine tall grass meadows, nival small meadows under the more extreme conditions there are encountered rhaponticum (*Fornicium* carthamoides), mountain willow-herb (*Epilobium montanum*), medow-grass (*Poa remota*), saxifrage (*Chrysosplenium baicalense*).

On the ledges in the cliff foots and at the riverbanks with pebble and sandy sustratum there is physochlaina (*Physochlaina physaloides*). Endemic species of the Baikal region are tussock-grass (*Deschampsia turczaninovii*) and cherepoplodnik (*Craniospermum subvillosum*) growing on the riverbed sands and the pebbles. Furthermore, for Khamar-Daban ridge there are typical narrowly local endemiks: svertia (*Swertia baicalensis*), monkshood (Aconitum sukaczevii), poppy (*Papaver turczaninovii*), tridaktilina (*Tridactylina kirilowii*). The rare species of the southwestern Baikal region have different status of protection and are included in the Red Books of different levels (Krasnaya kniga Irkutskoi…2010; Krasnaya kniga Rossyiskoi…2008).

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Regional natural complex, which was formed under the conditions of northern and eastern macroslopes of Khamar-Daban region, is unique. The high air humidity in summer and depth snow cover in winter create favorable conditions for the growth and domination of dark-coniferous taiga in the mountain taiga landscape okrugs (Suvorov 2002).

The species, composing dark coniferous forest group, possess at present the extensive Eurasian broken area. This was served as the proof of the myocene detachment of the dark coniferous taiga formation in the upper mountain belt from the Arctic Tertiary flora. The selection of species took place through whole period of dark-coniferous taiga existence (Malyshev and Peshkova 1984). Within the other territory of the Baikal Siberia with the low air humidity, contrasts of daily and seasonal temperatures, development of the seasonal and permafrost condition these conditions were, apparently, unfavorable for such species settling.

IV. Assessment of Forest Communities Sustainability

For revealing of contemporary area state, assessment of sustainability, functional connections between the components and composite parts of geosystems ecosystem approach has the most importance, its examines "ecosystem in the geographical medium" (Sochava 1978, p. 73). It is treated as revealing of interaction of biota, its elements and environment. Ecosystem approach is developing within the realm of the sciences of biological and geographical cycles: the landscape ecology (Forman 1986), landscape study (Sochava 1978; Mamai 1992), researches of vegetation and ecosystems (Schlueter 1987; Waide 1987; Shelyag-Sosonko et al. 1991; van Andel 2002; Kolomyts and Sharaya 2013).

The state of elements of physical geographical structures, landscape units of different levels is connected with the existing ecosystem connections, their manifestation in the longterm dynamics through the realization of the manufactured and fixed ecophysiological and genetic properties of plants in the prevailing ecologically differentiated environment.

Ecosystem sustainability depends on the comprising biotic components and stable existing system communications and living environment. Thus, variety and retention of plant communities within the specific territory reflects the stability of the retention of ecosystem connections. One of its characteristics-variety of flora composition.

The sustainability of vegetation is considered as the ability of plant communities actively to support and to restore its phitocoenosis structure and regimes of functioning within geosystems (Belov and Sokolova 2011), preserving in this case ecosystem relations and connections. The dynamics of plant communities realizes within the framework of their invariant, which corresponds to the existing stage of the historically prevailing conditions of the natural environment (Sochava 1979).

Under the contemporary physical geographical conditions with the prevailing diverse structure of anthropogenic actions as the basic external disturbing factor, which influences the natural trend of the forests dynamics, it is possible to divide the area into parts of the different temporary sustainability degree and conservation. The whole spectrum of this territory forest communities in the first approximation, can be differentiated to classes, which reflect their retention in up-to-date conditions. It was carried out the ranking, based on the expert assessments of plant communities taking into account their retention and degree of proximity to equifinal stages of successional conversions (table).

Table1: Integrated areas of sustainability of plant communities

Sustainability level	Plant communities indicators	Special features of development conditions and the nature of recovery
1. Stable	High mountain mountain-tundra willow-ernik and swampy sedge-cotton grass flattened Mountain pine of subgolets sparse woods Mountain taiga and submontane depression primary dark coniferous and light coniferous of slopes and of valleys Bogs and swamped meadows	Retard recovery under external disturbances. Low biotic diversity. Retard recovery after external disturbances. Ecologically favorable exsistence conditions and structure recovery. Optimal and partially limited development. Stable in spontaneous dynamics. of optimal development. prolonged-derived recovery stages under periodic anthropogenic impacts
	High mountain mountain-tundra of slopes Subgolets dark coniferous sparse woods, mountain pine communities and shrub thickets Sections of subalpine meadows and catchment lows	Retard recovery under external disturbances. Intensive slope processes Low biotic diversity. Retard recovery

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2. Moderate-stable	Dark coniferous sparse woods with meadows by places of upper belt of reduced development Dark coniferous sparse woods of reduced development upper belt, subshrub with mountain pine Mountain taiga primary dark coniferous at steep slopes Mountain taiga and submontane depression light coniferous prolonged-derived of successional stages and shrub-gramineus-forb medow prolonged-derived	after disturbances. Intensive slope processes High biotic diversity. Retard recovery after disturbances Narrow ecological species amplitude. High biotic diversity. of limited development conditions. Slope processes of limited development conditions Active slope processes. of limited development conditions of limited and optimal development conditions. Active slope processes. Under periodic anthropogenic impacts
3. Weak-stable	High mountain alpinotype short grass meadow communities Mountain taiga primary dark coniferous and sparse wood with mountain pine of reduced development upper belt at steep slopes	Narrow ecological species amplitude. Active slope processes of limited development conditions. Intensive slope processes.
4. Unstable	Mountain taiga of different altitudinal belts, including false-golets belt, of small-leaved short-time-derived successional stages Unclosed groups of grasses within high mountains with active slope processes	Favorable conditions of structure recovery. Intensive slope processes. Active denudational processes. And unstable recovery under changeable conditions
4a.Unstable anthropogenic transformed	Stable-derived communities of active land use	Stable under constant anthropogenic impact

Basing the map of contemporary state of vegetation (Novitskaya and Suvorov 2012) cartographically integrated areas of stability were represented (Fig. 3).

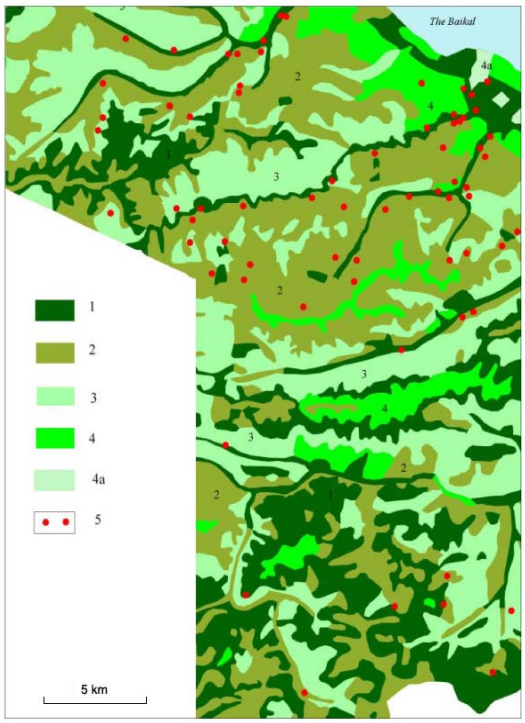


Fig.3: Fragment of the map "Sustainability of vegetation communities and ecosystems of Southwestern Pribaikalie

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Integrated areas of sustainability of plant communities and ecosystems: 1 – stable, 2 – moderate-stable, 3 – weak-stable, 4 – unstable, 4a - unstable anthropogenic transformed. 5 – rare species locations.

To stable it is related the plots of the preserved different types forests and other communities, due to their dynamic state close to primary states with the ecologically tolerant conditions for existence and structure renewal, for which is characteristic the stability of spontaneous dynamics, but at the same time retarded recovery after external structure disturbances. There equifinal succession forms of communities prevail.

To moderate-stable there are related the sections with the primary and prolonged-derived communities with active manifestation of the repetitive external factors of action, predominantly in the form of exogenous processes, which have an effect on background spontaneous dynamics. For them there is also peculiar retarded recovery and mainly limited development.

For the weak-stable sections it is characteristic the factor limited conditions for development, due to the narrow ecological range of plant communities existence and also caused by active exogenous relief processes.

To unstable it is related the sections with short-derivaed communities of restoring states of the different types of mountain taiga geosystems and with the high mountain communities under the extreme ecological conditions, and of also anthropogenic ally changed with the stable-derived communities of land active use.

The cartographically obtained integrated areas of sustainabiolity include different ecosystems, which have various mechanisms of the structure retention. Their uniting property is confinement to territorially compact areas with the retention of the existing structure. The high fragmented mosaic structure of the centers of the propagation of primary forest communities contributes to their steady retention.

V. Conclusion

For major part of the south Baikal area it is characteristic the domination of stable and moderate-stable preservable for estcommunities, extended in the mountain taiga belt of optimum development and the upper mountain taiga belt of limited development. Mosaic-dispersed distribution of forest communities of equifinal succession stages testifies about the up-to-date favorable conditions for retaining the dark coniferous forests in this region.

Anthropogenic impacts are noted mainly in the coastal zone along the railroad and the highways and next to the populated areas. There are concentrated the forest communities, which present in majority short-term-derived stages of the succession recovery. Their existence, especially near the large populated areas, is stable with the permanent anthropogenic press, and they remain long time as stable prolonged-derived communities.

The weak-stable and unstable mosaics of areas are almost continuous in lower mountain taiga belt and within adjacent submontane plains with sections of Baikal terraces. The propagation here of relict and rare plant species, which find favorable conditions for the growth, testifies about their unstable position as a result of anthropogenic press encreasing. It is necessary the complex assessment of location conditions and of state of plant populations at large-scale topological level. The territory of active anthropogenic action, including up-to-date economic infrastructure, is attached to the lake Baikal coastal zone, and the expansion of weak-stable and unstable areas is limited to the mountain conditions of locality.

The prevailing structure of this territory nature management and spatial differentiation of forest communities of the the southwestern Baikal region characterize the unique physical geographical conditions of retaining the dark coniferous taiga on the southeast of its propagation under the mountain conditions with the unique mosaic structure of areas stability.

The presence of a significant quantity of Tertiary relicts testifies about the long duration of favorable conditions for their existence at northeastern macroslope of Khamar-Daban ridge in the comparison with the entire territory of the Baikal Siberia, and also about the long continuance of interaction of the remainders of coniferous-broad-leaved and boreal flora through Holocene. To the retention of some species in the communities of mountain dark coniferous taiga it is contributed variety and mosaic propagation of locations (ecotopes) of mountain conditions.

For optimization of the regional system of nature management it is necessary to consider both the geosystem territory differentiation, which gives conditions for the propagation of different forest communities and species, and spatial heterogeneity of the areas of stability in the relationship of primary and derived structures under existing forms and the intensity of anthropogenic action.

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