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Formation of an Ecotone at the Boundary of Forest and Mountain Tundra

—Morskoy Ridge as an Example, Middle Part of Eastern Coast of Lake Baikal

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Abstract

During last decades, new trends appeared in the ecotones of the upper boundary of forests at the ridges surrounding Lake Baikal: ones to advance of wood species (*Pinus sibirica* Du Tour, *Abies sibirica* Ledeb., *Larix sibirica* Ledeb.) out of timber stands into the area of sub-goltsy with *Pinus pumila* (Pallas) Regel. up to mountain tundras. In average, this is from 100 to 200 - 300 meters in linear distance from the margin of dense timber stand. A burst of forests renewal occurred in 1989-1995, it resulted probably from a high productivity of the seeds of wood species due to warmer winters in 1980ies-1990ies which favoured the formation of favourable climate-edaphic conditions for the development of forest communities above the forests boundary on the ridges surrounding Lake Baikal.

Keywords

Ecotone, Boundary of Forest and Mountain Tundra, Eastern Coast of Lake Baikal

Subject Areas: **Biogeography**

1. Introduction

Studies of vegetation in ecotones “forest-mountain tundra” and in transitional cenoses of mountain belts of the Baikal Region are performed with support of an RFBR grant. The aim of our studies is to reveal spatial and temporal variability of forests upper boundary on the ridges surrounding Lake Baikal as well as trends of inter-height cenoses formation for diagnostics of existing and probable changes in vegetation structure of mountain systems on the background of climate dynamics in the region during last decades.

The Sukhaya R. basin served as a model territory for studies (upper reach of the river tributaries in the area of

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Davydov golets within Morskoy Ridge, middle part of Lake Baikal eastern coast). One of the main tasks of this work is to reveal structural and dynamical organization and variability of cenoses of transitional (ecotone) territory between polydominant dark coniferous–light coniferous and dark coniferous taiga of mountain systems of Lake Baikal eastern coast and cenoses at contact sites "forest-subgoltsy belt", "forest-mountain tundra" on the background of changing climatic conditions in the region. It is known that ecotones cenoses reflect not only the history of previous climatic impacts but also a trend of their future variations. Therefore, they can be considered as rather efficient and reliable proxies of spatial and temporal variation of the vegetation cover at wide territories. If zonal and belt changes in vegetation are characterized by a significant inertness, under transitional conditions (ecotones) they occur with a high dynamism. Hence, studies of phytocenoses under such physical and geographical conditions allow determining the direction of vegetation development at a concrete territory during a relatively short time period.

2. Research Area, Methods and Materials

Area our investigation is a middle part of the eastern coast of Lake Baikal basin as an example for research. Main methods of our studies are geobotanical descriptions with the soil-geobotanical profiling and use of materials of forest taxation from different years and seasons concerning key (model) sites relating phytocenoses to typological composition of soils and taking into account habitats orography allowed to reveal rather self-contained phytocenoses-ecotones as "forest-mountain tundra" plant communities. The "forest-mountain tundra" is area where the canopy trees stand challenges into mountain tundra including the subgoletsy subbelt as well.

3. Results

The selected key size is the Sukhaya R. basin (surroundings of Davydov golets, Morskoy Ridge), which reflects, in our opinion, main aspects of modern direction of forests formation in mountain belts of the middle part of Lake Baikal eastern coast. Some peculiarities of spatial and cenotic organization of vegetation in this territory are presented in some papers [1]-[3]. The results of paleogeographical studies suggest that since the beginning of Middle Holocene to Late Holocene, spruce and fir fraction decreased, and cedar fracture increased at the studied territory and in its surrounding area (Lake Baikal eastern coast) due to decrease of general humidity in the region [4]. Nowadays we observe the reversal situation—increase of fraction of dark coniferous species among polydominant dark coniferous–light coniferous forests everywhere.

General characteristics of vegetation in the studied area. According to correlational ecological phytocenotic map [5], vegetation units of the territory are represented mainly by fir-cedar forests with bilberry bushes, short grasses and green mosses, by cedar and cedar-spruce forests with undershrubs and green mosses and by their birch-aspen reconstitution series of temporarily cold and humid habitats together with low- and middle-mountain pine and larch-pine steppe forests with fragments of steppe meadows and with psammophytoc groups of Lake Baikal shoreline.

According to the map of zones and belts types of vegetation of Russia and adjacent territories [6], the studied area is related to Trans-Baikalian goltsy-tundra-elfin wood-light forest-taiga-forest steppe type of vegetation belt. There are such bars as mountain tundra, subgoltsy subbelt, subbelt of larch open stands with dark coniferous species admixture, lower bar of mountain taiga cedar-fir forests, lower bar of pine-larch and larch forests. According to the map of land use of the south of East Siberia [7], the forests of this area are within the water protection zone of Lake Baikal basin together with forests for agricultural usage. Studies of vegetation on this key site allowed to reveal the structure of forests from the upper reach of a tributary of the Sukhaya R. (Doshchaty creek) up to subgoltsy belt in the surrounding of Davydov golets (descriptions No. 2-7) including the description of cenoses structure of the Koma R. upper reach (the boundary of subgoltsy belt and mountain dark coniferous taiga), this is territory of watershed of the Sukhaya and Koma RR. basins (description No. 1).

Description No. 1 (N52˚25'123" - E107˚29'465"), h = 1319 m asl (clutters deposits are available)—upper reach of the Koma R., subgoltsy belt, watershed of the Sukhaya and Koma RR. basins. At the boundary of forest and subgoltsy belts there are well developed cenoses consisting of cedar (*Pinus sibirica*) under 80 y.o. in the first layer, cedar (*Pinus sibirica*), fir (*Abies sibirica*), spruce (*Picea obovata*) and larch (*Larix sibirica*) under 40 - 60 y.o. in the second layer with mountain pine inclusion (*Pinus pumila*), ledum (*Ledum palustre* ssp.-*Ledum decumbens*), bilberry (*Vaccinium uliginosum*) and juniper (*Juniperus sibirica* [8]) in the undergrowth with the soil cover consisting of bergenia (*Bergenia crassifolia*), crowberry (*Empetrum nigrum*) and rare moss synusiae

(*Polytrichum commune, Aulacomnium palustre, Climacium dendroides, Pleurozium schreberi, Dicranum polysetum, Abietinella abietina*) characteristic for dark coniferous taiga. The forming cenoses of subgoltsy forest consist of mountain pine (*Pinus pumila*) and bergenia (*Bergenia crassifolia*) with young growth of cedar (*Pinus sibirica*) and fir (*Abies sibirica*) under 15 y.o., with some trees up to 25 - 30 y.o.

Description No. 2—upper reach of the Sukhaya R. tributary (Doshchaty creek). Burn-out of 1993-1995. Reconstitution of pine forest (*Pinus sylvestris*) with inclusion of cedar (*Pinus sibirica*) via formation of birch forest. There are cedar under 40 y.o. and spruce (*Picea obovata*) under 15 y.o. Soil cover consist synusially of sedge (*Carex macroura*) and of mosses—*Abitinella abietina, Dicranum polysetum* and *Hylocomium splendens*.

Description No. 3 (N 52˚30'520" - E107˚22'411")—upward from Doshchaty creek (tributary of the Sukhaya R.) to the subgoltsy belt. The lower part of the slope of south-western exposition, h = 998 m asl. The cenoses consists of pine trees with larch (*Larix sibirica*) with inclusions of cedar, birch (*Betula pendula)* in the first layer. Pine, cedar, fir (*Abies sibirica*) and spruce (*Picea obovata*) form the second layer of timber stand in the cenosis. The undergrowth is dominated by pine with inclusion of cedar, fir and spruce. The undershrub layer is represented by blueberry (*Vaccinium myrtillus*) and honeysuckle (*Lonicera pallasii*) with soil cover of cowberry (*Vaccinium vitis-idaea*), may lily (*Maianthemum bifolium*), twinflower (*Linnaea borealis*), Lobel hellebore (*Veratrum lobelianum*) and mosses synusiae characteristic for polydominant light coniferous—dark coniferous taiga. At present, phytocenoses form with a trend to change forest forming species from light coniferous to dark coniferous ones, respectively.

Description No. 4 (N52˚30'780" - E107˚22'507"), h = 1090 m asl-middle part of the slope of the southwestern exposition. The first layer of the timber stand in the cenosis consist of larch with pine inclusion, the second one—of cedar, fir, larch. The undergrowth is dominated by cedar with considerable inclusion of fir and larch from 5 to 15 y.o. There are everywhere sprouts of fir and cedar. The undershrub consists of bilberry and juniper with soil cover of twinflower, sedge (*Carex macroura*) and mosses synusiae.

Description No. 5 (N52˚30'867" - E107˚22'511")—upper part of the slope of the south-western exposition (h = 1146 m asl). Foredt containing pine with larch (*Larix sibirica*) and cedar in the first layer, underwood of juniper and inclusion of mountain pine, moss—undershrub (bilberry, cowberry, twinflower)—motley grasses (*Calamagrostis neglecta*, *Carex macroura*, *Sanguisorba officinalis*, *Chamerion angustifolium*, *Lathyrus humilis*, *Vicia nervata*, *Helictotrichon schellianum*, *Maianthemum bifolium*). The second layer consists of pine with cedar, fir and birch (*Betula pendula*), the undergrowth is permanently dominated by cedar and fir with inclusion of pine and spruce. Fir and cedar trees 2 - 5 y.o. occur everywhere. Probably, these cenoses (description No. 4,5) represent the process of initial stage of formation of dark coniferous taiga on the site of light coniferous forest, somewhat with reflection of “interheight-belt ecotone” in development of this part of vegetation at this area of Morskoy Ridge.

Description No. 6 (N52˚31'119" - E107˚22'518")—near-top part of the slope of the north-western exposition at the boundary with subgoltsy belt in the surroundings of Davydov golets (h = 1241 m asl). Forest containing cedar and fir with rare inclusion of pine and larch, as well as of green mosses and bergenia. The first and the second layers are dominated by cedar while the undergrowth is dominated everywhere by fir with young growth of fir and, rare, cedar. The underwood consists of mountain pine, *Dushekia fruticosa* with inclusions of juniper (*Juniperus sibirica*) and bilberry (*Vaccinium myrtillus*). In the soil cover, besides bergeniz (*Bergenia crassifolia*), there are synusial inclusions of twinflower (*Linnaea borealis*) and mosses, edificators of dark coniferous taiga.

Description No. 7—transition of canopy timber stand of cedar and fir with mountain pine in the underwood into subgoltsy belt. Forests in the zone of transition into subgoltsy belt (N 52˚31'303" - E107˚22'578") and partly cenoses of subgoltsy belt were impacted by fires in 1993 (h = 1283 m asl).

On the burn-out site, the vegetation grows again, everywhere mountain pine, bergenia and cowberry grow, there are rare fir and cedar 2 - 10 y.o. In the kept bushes of mountain pine in the subgoltsy belt itself (rear part of the photograph) there is undergrowth of fir and cedar up to 15 - 20 y.o. as as clumps between boulders. In this case, despite fires impact, trees species invade into the subgoltsy belt. This closely correlated with data of performed studies of the dynamic of forest upper boundary along other mountain systems around Lake Baikal, in particular, for different sites of Khamar-Daban, Primorsky and Baikal’sky Ridges.

Compiled soil geobotanical profile for the key site revealed as well modern trends of vegetation formation in the contact area “forest—subgoltsy belt—mountain tundra” with invasion of trees species into the subgoltsy belt, where there are single fir and cedar trees in the cenoses on the soils typical for subgoltsy belt and mountain tundras [9].

4. Conclusions

Common characterization of forests structure in this region consists of trend of increase of the positions of dark coniferous species in the undergrowth of polydominant dark coniferous–light coniferous forests, where there is developed undergrowth of trees forming a dark coniferous taiga in a definite height belt characteristic for Morskoy and Khamar-Daban Ridges (middle part of Lake Baikal eastern coast). We have to notice that at present there are trends to change the upper forest boundary at this key site with formation of ecotone at the site of contact of canopy timber stand and subgoltsy belt ("forest-subgoltsy belt").

A similar situation in the development of phytocenoses at the contact of forest and mountain tundra is found out as well on other territories—within Baikal'sky (Davan pass, upper reach of the Goujekit R., North-Western Pre-Baikal) and Primorsky (surroundings of Sarma golets, central part of Lake Baikal western coast) Ridges, in different parts of Khamar-Daban Ridge (upper reaches of the Osinovka and Mishikha RR., Southern Pre-Baikal).

It is to notice that besides replacing of dark coniferous–light coniferous taiga to dark coniferous compound everywhere, one can foresee an active invasion of dark coniferous species into subgoltsy belt (in this case) and into mountain tundra in the whole region.

To verify these processes in vegetation development on above-mentioned territories, we need further studies on key sites of other areas in the mountain system of all Lake Baikal surrounding area using geobotanical survey, making large-scale schematic maps and soil-geobotanical profiles representing spatial and temporal variability in the structure the Baikal Region vegetation on the background of climate dynamics during last decades.

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