

TRENDS IN FORMATION OF PHYTOCENOSIS UNDER THE INFLUENCE OF NATURAL AND ANTHROPOGENIC FACTORS DURING LAST DECADES IN THE BAIKAL REGION

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ABSTRACT

The paper presents data of perennial studies of vectors of vegetation formation, in particular, forests development within steppe (extrazonal) coenoses on the western shore of Lake Baikal. Forestation processes on the territories occupied by steppes continue there. We showed modern trends of forests formation on sites where burning occurred during different years and with different intensity. It is stated that on the site of burnt primary coniferous taiga secondary forests develop. They consist of small-leaf trees species represented by their sparse undergrowth and clumps or single specimens everywhere.

Key words: forests, steppe coenoses, forestation, Lake Baikal western shore, burnt sites, secondary forests, South-West Trans-Baikal.

INTRODUCTION

The response of vegetation onto changing environmental conditions in space and time has different vectors and depends on physical-geographic conditions of concrete territories. While assessing changes in spatial stratigraphy of different types of phytocoenoses including forests, it is necessary to take into account the history of their formation and climatic cycles of different time intervals. Periodic fires of different intensity are to be considered as main anthropogenic factors influencing formation and development of vegetation. In the Baikal Region, besides the latter factor, the forests were and are used during a long period as a wood stock, and this influences directly forests formation and development with trend toward replacement of primary coniferous copenoses by their secondary components consisting of leafy trees species. Some areas in Pre-Baikal and Trans-Baikal serve as examples of their modern state, the vector of natural development and of anthropogenic destructions of vegetation in different environments of the Baikal Region. The aim of the study is to reveal a vector of natural development and anthropogenic destructions in vegetation from different environments of the Baikal Region (illustrated by some Pre-Baikalian areas). The studied objects were phytocoenoses of contact between forests and extrazonal steppe of Lake Baikal western shore; coenoses forming on burnt sites of West-Trans-Baikal forests.

MATERIALS AND METHODS

Research methods were geobotanical survey (Field Geobotany, 1964, 1976; Methods for Geobotanical Research, 1996; Methods of Geobotanical Mapping and Profiling, 1996) during several years and vegetation periods with making geobotanical description together with field deciphering of space pictures made in different years. Species composition of vascular plants and mosses in the cenoses was specified using existing keys (Flora of Central Siberia, 1979; Flora of Siberia, 1987-2003; Summary of Siberian Flora (Vascular Plants), 2005; Summary of Flora of Asian Russia (Vascular Plants), 2012; Bardunov, 1969, 1992). On the map putted the areas of study (see Fig. 1).

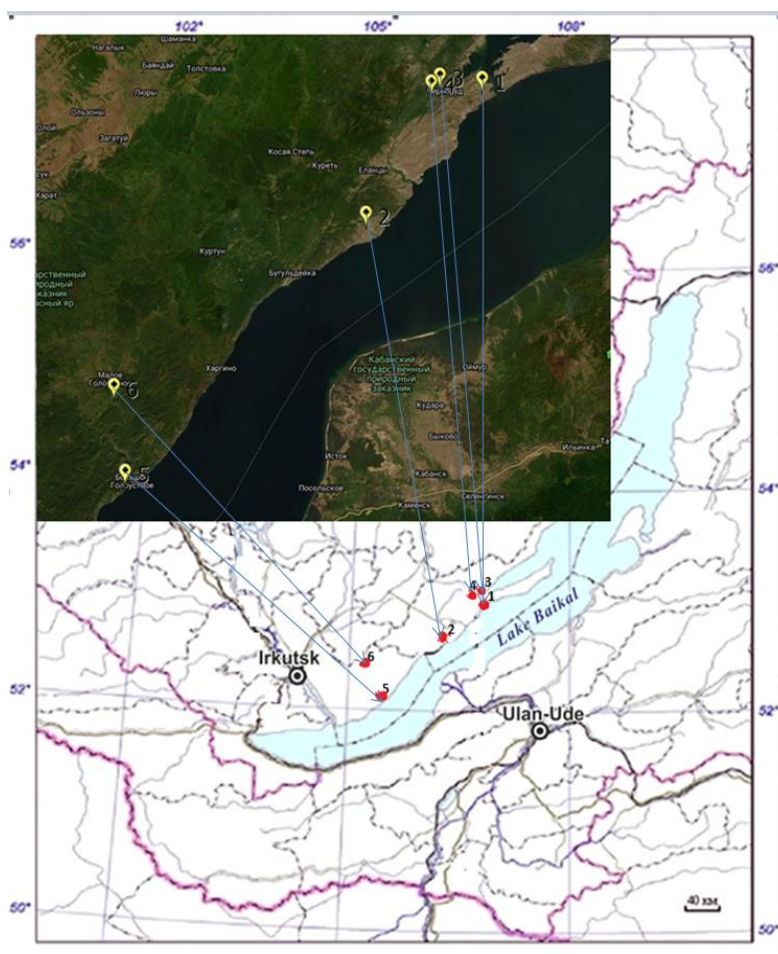


Figure 1. Areas of study: 1 - Pre-Ol'khon (Maloe More coast); 2 - Pre-Ol'khon (valley Shirokaya); 3 - Kuchelga R. (left side), which flows into Maloye Morye; 4 - Kuchelga R. (right side), which flows into Maloye Morye; 5 - the Goloustnaya R., which flows into lake Baikal; 6 - the Goloustnaya R. basin (middle part).

RESULTS

Perennial geobotanical survey using spatial pictures of different years, which served as a part of monitoring of phytocoenoses formation at contact of forests and extrazonal steppe in Pre-Ol'khon (Lake Baikal western shore), allowed to find out that light-coniferous forests together with steppe coenoses are by their essence a unit in

phytocoenogenesis process with a trend towards forests formation. Spatial-temporal variation of such coenoses manifests the peculiarities of vegetation genesis under contrast environmental conditions in the studied area. Decrease of areas occupied by steppe coenoses during recent decades in Pre-Ol'khon (Lake Baikal western shore) may be due to falling of main amount of summer precipitations during late summer and autumn, as well as to increase of the snow cover; however, partly it is due to anthropogenic impact in the region – decrease of use of these land for pasturage during recent decades. Taiga steppe coenoses form in the studied area under the conditions of steppes extrazonality (Steppes ..., 1991, Steppes central ..., 2002) with non-expressed mountain and mountain – forest-steppe belts (by geoelemental composition and by composition of belt-zonal plants groups in the coenoses). By the character of their development, they represent a demutation-reconstitution stage of the development of polydominant light-coniferous forests of a zonal type. It is known that by ratio of temperatures, precipitations and radiation balance the zonality is primary, the belts are always secondary. The pictures presented below fixed modern trends of forestation of extrazonal steppes on some territories in Pre-Ol'khon (Fig 1-1; Fig. 1-2).

The picture below (Fig. 1-1, Pre-Ol'khon, Maloye Morye coast) presents sparse stand and undergrowth of larch (*Larix sibirica*) from 5 to 18-20 y.o. within steppe coenoses out of closed timber stand on the slopes and their trails of different expositions (distant plan of the picture) and along intermountain bottoms (foreground of the picture) everywhere within the studied area. On the distant plan of the picture within extrazonal steppe, there are larches (*Larix sibirica*) of different age – from 5 to 18-20 y.o. Separately situated larches groups (foreground of the picture) at the boundary of closed timber stands and extrazonal steppe are characterized by synfolia differentiation with undergrowth up to 5-7 y.o. with soil cover consisting of steppe and forest plants species with synusia of mosses characteristic for the soil cover of light-coniferous taiga.



Figure 1-1. Open woodland of different age, steppificated, consisting of larch (*Larix sibirica*) with inclusion of pine (*Pinus sylvestris*) among extrazonal steppe coenoses in Pre-Ol'khon (Lake Baikal western shore).

The field deciphering of space pictures (Data INTAS Project 99-1669 Image 2022 CNES/Maxar Technologies, survey date April 9, 2021) allowed to make a schematic map of spatial stratigraphy of forest and steppe (extrazonal) coenoses in time. The schematic map presented below (Fig. 1-1a) reflects forestation processes in extrazonal steppes on the territory of Central Pre-Ol'khon (Lake Baikal western shore) during last 40 years.

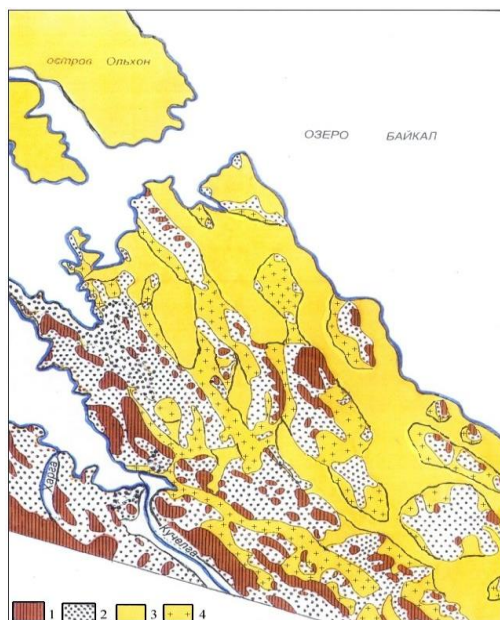


Figure 1-1a. Central Pre-Ol'khon (Lake Baikal western shore). The schematic map of vegetation structure on Maloye Morye shores shows a spatial ratio of composition of forest and steppe coenoses.

Legend of the schematic map: Brown straight-line tint shows closed forests, yellow one – steppe territories occupied by steppes. Markers (+) show sites of forestation of steppe territories for 2022; 1 – forests consisting of larch (*Larix sibirica*), green mosses with larch undergrowth; pine (*Pinus sylvestris*) with larch; pine and larch with undergrowth of pine, larch, with inclusion of cedar (*Pinus sibirica*), green mosses, motley grasses; 2 – open woodlands with motley grasses, steppificated with mosses synusia, consisting of larch with undergrowth clumps at the boundary with steppe coenoses (for 2002); 3 – extrazonal steppe coenoses consisting of motley grasses and cereals with undergrowth of larch and pine in them (for 2002); 4 – open woodlands of larch (*Larix sibirica*) with motley grasses, synusia of mosses in unit with steppe coenoses with larch undergrowth in them (for 2022).

The picture below (Fig. 1-2.) presents pines (*Pinus sylvestris*) of different age (from 5 to 18-20 y.o., some trees up to 45 y.o.) as groups and single trees (foreground of the picture) within extrazonal steppe coenoses everywhere. The distant plan of the picture presents pine forests along the slopes of different expositions and narrow valleys with inclusion of larch (*Larix sibirica*), rhododendron, cowberry, often containing in the soil cover mosses characteristic for zonal dark-coniferous – light-coniferous taiga. Pine (*Pinus sylvestris*) undergrowth, with single trees up to 50-60 y.o., out of closed timber stand (distant plan of the picture) is characteristic for the whole territory of the key site – creek valley Shirokaya (Pre-Ol'khon, valley Shirokaya).



Figure 1-2. Open woodland of different age, steppificated, consisting of pine (*Pinus sylvestris*) in Pre-Ol'khon (creek valley Shirokaya, Lake Baikal western shore западное побережье оз. Байкал).

On the base of field deciphering of a spatial picture (Data INTAS Project 99-1669 Image 2022 CNES/Maxar Technologies, survey date April 9, 2021), we made a schematic map (Fig. 1-2a) of spatial structure of forests and steppe (extrazonal) coenoses of creek valley Shirokaya (southern part of Pre-Ol'khon), which reflects modern trends as well towards further forestation of steppe territories of Lake Baikal western shore.

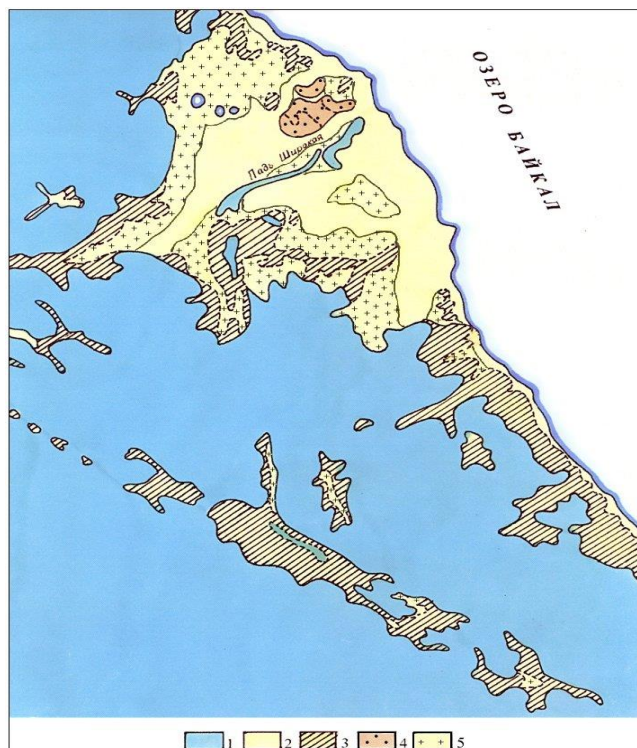


Figure 1-2a. Creek valley Shirokaya (South Pre-Ol'khon, Lake Baikal western shore). The schematic map reflects spatial stratigraphy of forest and steppe (extrazonal) coenoses.

Legend to schematic map: Straight-line tint shows steppes territories afforested by 2002. Markers (+) show sites afforested by 2022-й. There are trends of vegetation formation similar to ones on previous site of the studied area – a gradual forestation of extrazonal steppe occurs; 1 – larch-pine forests with motley grasses and mosses synusia; 2 – cereals – motley grasses coenoses with single pine and larch trees (for 2010); 3 – open woodland of pine of different age (from 2 to 45 y.o.) out of timber stand canopy (for 2010); 4 – overgrowing burnt site of 2002; 5 – pine undergrowth with some trees up to 20 y.o. in a unit with steppe extrazonal coenoses. There are trends in vegetation formation similar to previous site (Fig. 4) of the studied area – a gradual forestation of extrazonal steppe occurs in this Pre-Baikalian area.

Concerning the illustrations above (Figs. 1-1, Figs. 1-1a; Figs. 1-2, Figs. 1-2a), we have to notice that by characteristics of spatial structure, steppe zones of Central Asia (Steppes of Eurasia, 1991; Steppes of Central Asia ..., 2002), extrazonal steppes of the studied area (Pre-Ol'khon, Lake Baikal western shore) are not related to any area and subarea of a steppe type of vegetation. The studied area is characterized by forests consisting of pine (*Pinus sylvestris*); larch (*Larix sibirica*) – pine and larch (in some cases there are trees of cedar (*Pinus sibirica*) from 2 to 28 y.o.) including rhododendron (*Rhododendron dauricum*), duschekia (*Duschekia fruticosa*), cowberry (*Vaccinium vitis-idaea*), motley grasses as well as undershrubs and green mosses with secondary groups of aspen (*Populus tremula*) and birch (*Betula platyphylla*) instead of them. The slopes of north-eastern and north expositions are occupied by pine-larch and large forests including duschekia, cowberry (*Vaccinium vitis-idaea*), motley grasses (with cedar up to 10–18 y.o.) and larch forests including shrubs, sedge, motley grasses, green mosses, which form on low and middle parts of the slopes of different expositions. Mountain-steppe and mountain – forest-steppe belts in vegetation structure are not expressed, and timber stands with a stable undergrowth and pine and larch sprouts

form among extrazonal steppe coenoses; so, we can state a formation stage on the territories occupied with steppe coenoses of Pre-Baikalian coniferous forests. Presence in the soil cover of mosses characteristic for dark-coniferous taiga confirms well the formation of zonal type of vegetation – taiga.

There is another example: similar forestation processes in an extrazonal steppe (Steppes of Eurasia, 1991; Steppes of Central Asia ..., 2002) on other Pre-Ol'khon site – central part of Lake Baikal western shore in the basin of the Kuchelga R. (left side), which flows into Maloye Morye. Larch (*Larix sibirica*) forests with cereals and motley grasses form there during many years among steppe coenoses; they are steppified with different age with trend to forestation of territories occupied with extrazonal steppe along the whole river basin. The soil cover, besides steppe plants species, there are often mosses species (*Hylocomium splendens*, *Dicranum polysetum*, *Abitinella abietina*, *Polytrichum commune*, *Rhytidium rugosum*) characteristic for light-coniferous – dark-coniferous taiga. It is possible as well to state here that a larch forest of zonal type forms instead of an extrazonal steppe (Fig. 3).



Figure 3. Thinned steppified larch (*Larix sibirica*) forest of different age with motley grasses.

There is a remark: among phytocoenoses at forest and extrazonal steppe contact in the studied area (right side of the Kuchelga R. basin, Central Pre-Ol'khon), there are plants species characteristic both for forests and for steppes. On the picture below there are dianthus (*Dianthus versicolor*) and delphinium (*Delphinium grandiflorum*), steppe species in sedge (*Carex macroura*) – moss soil cover in a larch (*Larix sibirica*) forest – light-coniferous taiga. Is this extrazonal steppe forestation of zonal forests steppification? If we take into account that during the first half of the last century steppe coenoses formed instead of cut larch forest, it is possible now to state the development (return) of a forest coenosis. The process of forestation of an extrazonal steppe in Lake Baikal basin is of regional scale (Fig. 4.).



Figure 4. Soil cover consisting of steppe and forest species of plants of open woodland of larch (*Larix sibirica*) forming on banks of the Kuchelga R. (Central Pre-Ol'khon, Lake Baikal western shore).

The picture below reflects the processes of forestation of extrazonal steppe in the southern part of Lake Baikal western shore (the Goloustnaya R., which flows into lake Baikal). Steppified pine (*Pinus sylvestris*) forests with a very close timber stand including motley grasses form at the first development stage (Fig. 5).



Figure 5. Pine (*Pinus sylvestris*) undergrowth in steppe (extrazonal) cenoses of demutational series – reconstitution of forest consisting of pine, motley grasses and sedge of zonal type characteristic for the South Pre-Baikal.

Forestation of extrazonal steppes on Lake Baikal western shore alleviates the boundaries between a forest and a steppe with reducing of territories occupied by steppe coenoses everywhere. At modern stage of vegetation development, larch forests (on Maloye Morye shore) and pine ones (in creek valley Shirokaya and in the Goloustnaya R. basin) form further. We have to notice here that such processes of formations are characteristic for the whole Lake Baikal western shore. Activation of forestation of steppe areas as a process of return of a forest “to its place” as clumps of larches of different age and pines among extrazonal steppes with abundant undergrowth as well as presence of mosses characteristic for the soil cover of dark-coniferous – light-coniferous forests suggest processes of reconstitution of forest (zonal) vegetation type in Pre-Baikal.

Fires are a considerable, often disastrous factor influencing the formation of forest vegetation in the Baikal Region. Let us consider some examples of consequences of fires of different intensity in the forests in some Pre-Baikalian areas (Fig. 6). Small-leaf groups of reconstititional series of primary forests formed instead of a burnt (30 years ago in the Goloustnaya R. basin) forest, which consisted of pine (*Pinus sylvestris*), larch (*Larix sibirica*), green mosses and cowberry (*Vaccinium vitis-idaea*). Under the canopy of birch (*Betula platyphylla*) and aspen (*Populus tremula*) there is a very sparse undergrowth of pine from 2-5 to 10–15 y.o.. Reconstitution of primary coniferous taiga will last for a long period if new ground fires are excluded. Such situation is characteristic for light-coniferous forests for the whole basin of the Goloustnaya River basin (middle part).



Fig. 6. Formation of sparse undergrowth of birch (*Betula platyphylla*) and aspen (*Populus tremula*) with single trees of pine (*Pinus sylvestris*) on the site of burnt forest, which consisted of larch (*Larix sibirica*), pine (*Pinus sylvestris*), motley grasses and sedge (*Carex macroura*) with inclusion of mosses.

CONCLUSION

- Trends towards forestation of an extrazonal steppe of Lake Baikal western shore are characterized as “pressing” of steppe space at the actual stage of vegetation development. In this case, forming taiga-steppe cenoses of Pre-Ol’khon are proxies of changing environmental conditions in the region (in particular, increase of snow cover thickness during recent years). However, forestation processes in extrazonal steppes will be constrained by anthropogenic factors – forests cutting at the contact with an extrazonal steppe and burning of the undergrowth out of timber stand canopy in order to keep and extend pasture area.
- Modern trends of forests reconstitution on burnt sites are characterized by formation of timber stand consisting of small-leaf species (birch, aspen) at the first stage (succession) of the development. Appearing of sprouts and undergrowth of main coniferous forest forming trees species characteristic for forests of zonal type.

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