ECOLOGY OF LOWER TREELINE OF KURAI INTERMOUNTAIN DEPRESSION (CENTRAL ALTAI)

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ABSTRACT

The lower treeline of the Central Altai is strongly affected by land use and grazing. Traditional ways of the Altai people land use before early XX century were non-exhaustive, the population numbers were low and therefore grazing impact was minimal. The growth of the human population and the increase of Chuyskiy Trakt importance caused increasing of sheep grazing. It was increased even more during Soviet period because of extensive approach to land use. Overgrazing and extensive tree cutting caused a significant rising of the lower tree line. The decrease of overgrazing caused by the dissolution of USSR and following the financial and agricultural crisis created the possibility of lowering of the tree line. The possible ways of tree line dynamics under the impact of modern climate change may be different. If the influence of climate change (warming and aridization in the case of Altai) is great enough the tree line would remain the same or continue rising. If the one was not enough strong the tree line would descend. Our investigation allowed us to fetch out slow descending of the lower tree line and presence of "overgrazed low *Artemisia* steppe -> regenerated *Stipa* steppe -> Young *Larix sibirica* forest with *Iris* domination in the grass storey" secondary succession. The succession is slowed down by the presence of grazing but looks sustainable. The situation is a great illustration of the fact the change of land use in some cases may be important for ecosystem rehabilitation and be enough powerful to counterweight climate changes at least for some time. It also confirms the earlier hypothesis on the great ecological amplitude of Larix sibirica which still successfully colonizes previously forested areas despite the mentioned climate changes.

Keywords: *Lower treeline; Mountain treeline; Siberian Larch; Mountain forests; Overgrazing;*

INTRODUCTION

The lower treeline of Altai mountains is strongly affected by over-grazing. The indigenous population (Altai people (Altaitst in Russian) which consists of about a half dozen smaller peoples divided by language and religion but having general ethnogenesis) activities was based around cattle-breeding for centuries. The traditional cattle-breading approaches assumed low population density and relatively low cattle population and was based on seasonal change of ranges from steppe-covered bottom of the inter-mountain depressions to the forest-steppe ecotones and forests of mountain slopes. The tree cutting was minimal and significantly regulated by the local shamanistic religion. The Russian colonization of the Altai mountains in the XIX century and the growth of the importance of the

Chuiskiy Tract road – the primary way of Russian-China trade of the past caused increase of the sheep population. The USSR development of Altai in the XX century has improved quality of life and cause growth of human population numbers. The planned economy of USSR and extensive nature of Soviet approach to the region's development are greatly affected the Altai by enforced growth of the cattle population and the introduction of industrial forest cutting. The powerful human impact causes anthropogenic rise of the treeline in all inter-range depressions where the human population was concentrated. The steppes in the depressions and on the slopes was overgrazed and turned to damaged *Artemisia*-dominated ecosystems with very little cover (20-40%). The failure of the planned economy caused a prolonged economical crisis of USSR at the 1980s and, finally, the dissolution of the USSR, which ended with the new economical crisis of 1990s. The crisis has significantly decreased cattle population of the mountain Altai and tree cutting volume decreased. Our survey made in the previous years indicated the current status of the inter-range depressions are not uniform: many depressions with higher numbers of human population along the Chuiskiy Tract are still strongly overgrazed but some remote depressions and depressions with smaller settlements are slowly recovering from overgrazing. One of such depressions is the Kurai depression limited by Severo-Chuiskiy range and Kurai range. The settlement of the depression is Kurai village settlement (50°13'N; 87°55'E) which include two villages divided by river with a total population 1262 (2016). The Kurai depression is a dry steppe area because most humid air masses are stopped by mountains. The steppe itself is strongly overgrazed and regeneration is observed only in some remote areas. The lower forest line was formed out at 1950s-1970s by tree cutting – total in lower parts and выборочной cut, which formed treeless strips in higher areas. The current altitude of the treeline is 1640-1710 m a.s.l. The most important tree species of the ecotone is the Siberian larch (*Larix sibibrica*). The species is highly resilient, easily survives cold winters with thin snow cover typical for the Kurai depression and grows faster than any other conifer tree of the Altai area [1], but it definitely prefers colder climate [2-3]. The cattle population in the Kurai settlement was decreased to levels just necessary for population sustenance. The cows and yaks are partially replaced sheeps and as a result grazing levels is decreased.

RESULTS

The modern regional level climate change studies [4] indicate the average increase of the mean annual temperature since 1980s was 3,8°C and precipitation decreased by about 10%. It is a significant change and naturally, we assumed the changes at treeline may come along several possible scenarios. . If the influence of climate change (warming and aridization in the case of Altai) is great enough the tree line would remain the same or continue rising. If the one was not enough strong the tree line would descend. To study possible treeline ecosystem dynamics we've made studies along three transects along the altitude gradient. Both transects were made on the norther slope of Severo-Vhuiskiy range and crossed the ecosystem from overgrazed steppe at lower parts to the closed forest in the upper parts. Along each transect we've studied we've made full standardized geobotanical descriptions [5] of 24-31 plots which was located in the representative ecosystems and their key

structural elements. We have chosen *parcellas* (the minimal element of ecosystem with uniform dominant species of the ground cover [6] – уточнить определение парцеллы) as a key structural element. The approach was used before all ecosystems near treeline is connected by the streams of matter, energy and information and should be studied as a system, not as isolated elements.

The lowest parts of all transects were highly disturbed and overgrazed ecosystems with a ground cover dominated by low herb (2-4 cm from the ground) *Artemisia tanacetiflolia.* The cover of this ecosystem is very low (20 to 40-45%), species biodiversity is also low (21-28 species, species density about 0,24 species / m^2). Above the overgrazed steppe we have found regenerating steppe; the open parts with ground cover dominated by typical steppe herbs *Stipa zelesskii* or *Helictotrychon altaicum.* The regenerating steppe may occasionally include scrub patches, mostly consisting of *Cotoneaster uniflorus*. In some areas of the steppe some groups of larch trees were left by lumbermen as soviet rules require. These patches were seen as a center of future forest regeneration but in the conditions of overgrazing this badly working method of forest preservation has failed. Despite the failure of regeneration these tree groups (so-called 'Kolkas') support isolated patches of forest-steppe ecotone ecosystems: they typically include 2 to 10 Larix sibiricus trees, scrarce shrub storey mostly consisting of Karagana arborescens and near 100% ground storey cover dominated by *Iris ruthenica, Astragalus austrosibiricus* with *Helictotrichon altaicum. Arthemisia santolinefolia* and *A. serices* which settle on the boundaries of the kolka. The larch seedlings were found in the kolkas and around them but no young trees were found.

The 70-80 m wide strip of regenerated steppe which adjoins the forest edge are ontain some isolated young larch trees (height about 60 cm) but very little number of seedlings and very young larch individuals was found in the strip. The wideness of the strip looks limited by the range of the larch seed wind transfer range. The larch containing are specific parcellas with shrub patches of C*aragana arborescens* and *Spiraea hypercifolia* which cover up to 15% of the entire parcella area; the ground cover is dominated by *Iris ruthenica* and *Helictodtrichon altaicum;* the rest part of the strip is the typical regenerated steppe with patches of *C. arborecens* and *Cotoneaster uniflorus* shrubs. The larch-containing parcellas are typical ecotone communities; they may include up to 27 species with mixed ecological preferences – the typical forest species Iris ruthenica are intermingled steppe grasses and herbs.

The closed forest is divided from the steppe by a shrubby margin. The tree storey of the margin include adult thin larch trees with height up to 2,5 m; Dense shrub storey has cover about 60% and mostly consist of *Caragana arborescencs* and *Cotoneaster melanocarpus*, ground storey is dominated by *Iris ruthenica* and *Eleocharis sp*., but presence of the steppe herb *Artemisia tanacetifolia* is also significant. The *Larix sibirica* regeneration consisting of young larch trees from 0,3 to 1,2 m height are present, but presence of seedling is minimal. We have found 44 species of vascular plants in the margin

Forest located behind the margin contains a number of steppe species and high proportion of steppe plants (mostly steppe grasses). It has width about 20-30 m and continues along the entire forest margin. Much like margin this forest strip is also

purely ecotone type ecosystem. The forest are somewhat rare (tree cover is about 20-25%) and consist of full size (4+ m) thin larch trees. The shrub storey is dense (45-50%) and mostly consists of *Caragana arborescens, Caragana bungii* and *Spiraea media* and covers about 50%; the ground storey mostly consist of *Poa pratenisis*, *Artemisia tanacetifolia*, *Iris ruthenica*, *Carex macroura* and *Serratula aligida.*

The biodiversity of the lower part of the forest is 35 species, but species composition suggest it is also colonized by some steppe plants and serves as upper part of ecotone.

Above this forest we can find densier forest with lesser presences of the shrubs and with ground cover dominated by *Iria ruthenica* and grasses of Carex and Poa genera. The forest is crossed with cutted strips with solid regeneration and a several younger larch tree groups with height from 0,3 m to 2 meters.

DISCUSSION

The studies along two altitudinal gradients divided by 7 km indicate that the lower treeline is slowly moving down (at least in northern part of the Kurai depression) and the global climate change impact is not strong enough here to cause moving of artificially elevated treeline and thus the climatic treeline should be below actual modern treeline.

The steppe below the ecotone slowly recovers after the overgazing and all recolonization of the steppe by the Siberian larch was found only in the recovered steppe what may prove the larch colonization is possible only in the normal steppe, not overgrazed one. The lack of the very young larch trees in the kolkas and in the ecotone strip may be caused by bad seed production or low quality of the seeds caused by weather impact or later climate changes, or some other causes like remaining grazing; additional investigations are required to understand the exact cause.

Our investigation allowed us to fetch out two secondary successions in the ecotone areas. The first one is a simple two-stage steppe regeneration succession (Artemisia-dominated steppe → Stipa and Caragana - dominated steppe) and the second one is the ecotone-moving secondary succession (Stipa and Caragana dominated steppe – Steppe with Iris and Caragana dominated patches -> Forest margin -> Larch forest) but exact time which is required for these successions and stability is also stll unknown.

CONCLUSIONS

The mountain Altai is a remote area where some areas with low disturbance levels caused by human impact are existing. The Kurai depression provides us with the rare and interesting situation where overgrazed steppe is slow recovering to normal one and the lower treeline formed by Siberian larch moves down, to previously cutted areas because of decreasing of human impact. Much probably the modern impact of climate change is not strong enough to prevent decreasing of the lower treeline. The changes of the steppe are probably one of the drivers of slow

decreasing of the lower treeline. The regeneration of steppe from sage-brush dominated damaged steppe to normal feather-grass (*Stipa zalesskii*) dominated one may be important driver of the treeline dynamics – it is probably decreasing of the altitude of lower treeline is impossible if the steppe below is too overgrazed. It is obvious that the climatic altitude of the treeline in the Altai mountain is lower than a modern one, formed by the impact of the tree cutting. The steppe below treeline is the subject of the pair of secondary succession: restorative succession and steppe-to-forest transformation succession.

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