Change in the agrophysical properties of frozen soils under anthropogenic effects

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Abstract. The article presents the results of studies of the agrophysical properties of the zonal soils of Central Yakutia formed under the line of larch of different-level cowberry. As human intervention in forest ecosystems increases, the fragile ecological balance of the existence of taiga-alasny permafrost landscapes, reflected in the properties and regimes of zonal soils, changes. Changes in the agrophysical properties of frozen soil directly affect the hydrothermal regime of the soil and, accordingly, the plant composition of the ecosystem. The obtained materials show a decrease in fertility and deterioration of the properties of frozen stick saltwater soils, their compaction and desiccation under the influence of ploughing during livestock crossing within forest between spaces. Destruction of ground vegetation reduces the natural thermal insulation of the frost and leads to an increase in the depth of seasonal soil weeding by 25%. The total anthropogenic impact leads to the destruction of taiga ecosystems and the degradation of the permafrost in Eastern Eurasia.

1. Introduction
In recent decades, man-made interference has intensified in the functioning of the natural frozen taiga -alasny landscapes of Central Yakutia, which are unique natural phenomena, where forest, steppe, meadow, mountain and Arctic plant communities grow next door in extreme climatic conditions. This impact is reflected in the increased scouring of forests for agricultural land, deforestation for power lines, roads, communication lines and water lines, as well as annual logging for heating and house construction, in connection with the expansion of settlements. In addition, forest fires destroy forest areas every year for tens of thousands of hectares. These processes are many times longer than the period of natural restoration of forest in permafrost. As a result, man-made effects on the soil and plant cover of Eastern Siberia disrupt the fragile thermal balance of the cryosphere, affecting the climate of the planet on a regional and global scale. Destruction of the forest leads to melting of many years of frost, settling of the soil, increased evaporation of soil moisture, and gradual formation of alasny pits. The prevalence of the grazing regime in the soil of alas leads to the tightening of easily soluble salts to the day surface, that is, salinization occurs, leading to a sharp decrease in soil fertility, as a result of which the species composition of vegetation changes towards the prevalence of low-value, weed herbs. Alasny meadows are the main feed base for livestock breeding of the Central Districts of the Republic, located geographically in the taiga zone. The degradation of the interconnected Taiga-Alas ecosystems and the reduction of alasny soil fertility is an important and urgent task that requires an adequate solution for the normal functioning of the national economy of the Republic.
 operationalize measures to increase productivity and manage natural resources. There is a need for a study of forest soil parameters of Taiga-alas landscapes, as the alasny soils are in a downward relief and are dependent on the condition and influence of adjacent clad forest areas that feed the moisture of the debt, which is extremely important in the arid continental climate of the region. This is also necessary to predict the transformation of feed resources and to identify ways to preserve ecosystems while increasing the trend of anthropogenic impact. Changes related to the destruction of forests are primarily reflected in the zonal soils of the Leno-Amgin inter-river [1, 2]. The aim of the research is to identify the transformations of the taiga ecosystems of permafrost as a result of the change of agrophysical properties of zonal soils under the influence of anthropogenisis.

2. Materials and methods
The area of research is in the Lena-Amga interfluve, where the zonal soils are unique murky palate soils (figure 1) formed under wooded vegetation represented mainly by Cajanderi larch (*Larix cajanderi* Mayr.). They are located in the permafrost zone and, of course, the above-mentioned changes are reflected in the properties and parameters of these soils. Research of agrophysical properties of zonal soils of Taiga-Alasic landscapes was carried out on the basis of "Allah," located on the Bestiakhsky terrace in the area of the right bank of the middle current of the river Lena.

![Figure 1. Location of the investigated in the Republic of Sakha (Yakutia), Russia.](image-url)
Here, as in the whole of Central Yakutia, the main background of light-armed taiga is represented by a larch of different-level-brushy, growing on frozen stick saltwater soils. According to Classification [3] these soils belong to the department of palate-metamorphic soils, type of palate, subtype of salt soils. According to the international classification WRB, they were defined as Haplic Cryosols (Albic, Calcaric, Luvic, Siltic, Sodic) [4]. Soil-forming rocks are formed on ancient alluvial deposits folded from well-sorted small sands and low-power pebbles containing carbonates. Studies of the basic physical properties of the soil were carried out by conventional methods. Forestry methods were used in the forest description of the trial area [5.6]. Interalasic spaces at the same time serve as sections of cattle passage from one alasic pasture to another, so there is intensive extraction and eating of live ground cover, as a result of which, larch of different-level-brushy platform 1 (pl.1) turns into larch of dead-blood platform 2 (pl.2). These sites are selected for comparative analysis of the effect of etching on agrophysical and chemical properties of single-type frozen palate soils.

3. Results and discussion
Frozen palate soils are divided into 3 main subtypes, typical, grey and saltwater [7]. Common for these soils is the presence of a carbonate horizon suspended in the middle of the profile with an alkaline reaction. The saltwater subtype has a white saltwater horizon under the humus layer, which is clearly released during visual inspection. The profile is identical to podzolic soils, but has, unlike acidic podzolic soils, an alkaline reaction of the environment. The frozen palace saltwater soils of the Bestiakhsky terrace are characterized by a light fraction composition associated with their formation on ancient alluvial sand deposits. These soils, according to the generally accepted classification, belong to large-scale soups. Particle size distribution analysis data (table 1) shows marked differentiation of genetic horizons in the soil profile and satisfactory agrophysical indices (pl. 1). Thus, at a depth of 10-20 cm, the eluvial horizon of the A2 is clearly separated, with the prevalence of a coarse fraction with sludge depletion (< 0.001 mm). The content of the sludge fraction in the illuvial horizon is B1 twice as high as in the A2 horizon. In the carbonate horizon, the sludge content decreases dramatically, and below it decreases evenly to the soil-forming rock, increasing slightly over the frozen screen. The accumulation of sludge in the illuvial horizon gives the soil a number of negative properties - reduced temperature-air and water permeability and compaction, which make it difficult to develop root systems of plants.

The destruction of the ground cover during plating (pl. 2) leads to degradation of organic substances with compaction of upper horizons, which in turn reduces the absorption capacity of the soil together with deterioration of hydrological constants [8,9]. At the same time destruction of vegetation cover weakens heat-insulating role of forest vegetation on perennial frost, thus increasing depth of seasonal-melt layer and desalination of soil profile, and this as a result determines gradual change of species composition of vegetation towards wither and reduction of productivity and species diversity of light-weight taiga.

4. Conclusions
The agrophysical properties of frozen soil are mainly determined by its particle size distribution composition. The frozen palate soils of the Bestiakhskaya terassa of the middle flow of the river Lena in the root-covered layer are satisfactorily microstructured, well air- and water-permeable, have loose addition and average density. In natural conditions, the value of HV is independent of the content of sludge particles, this dependence begins to manifest itself under anthropogenic action, in other words, the primary role in the water-retaining capacity of soils belongs to the content of organic substances in the soil profile, and then to the mineral sludge fraction.

In the embossing, the upper 10-centimeter layer is compacted, which is the main reason for the decrease in filtration capacity and the decrease in HB on the 10%. The macro aggregate composition is degraded and the soil becomes even more non-water-resistant in the near-surface layer. These changes, as the depth of seasonal soil thawing increases, result in soil layer desiccation and a decrease in the total fertility of the gutted section of the frozen palate salt soil, changing the species composition.
of vegetation towards more xerophytic species while reducing the total biomass. However, these areas may increase the fire hazard of forest areas under certain conditions (dry summer). And then further thawing of perennial freezing and failure of the day surface and formation or expansion of existing alasric pits. Thus, anthropogenic influence in the Central Yakutia relating to Eastern Siberia is shown indirectly, leading to the general total result - radical degradation of taiga ecosystems, influencing global climate change.

These initial soil values, under anthropogenic effects, change in a certain sequence and they are stretched over time, so knowledge of them will allow to purposefully improve and restore the parameters of frozen soils, which determine the condition of alasric-taiga landscapes of the medium-terrnary zone of the cryosphere in order to prevent or slow down irreversible transformations of frozen ecosystems.

**Table 1.** Particle size distribution (numerator) and microaggregator (denominator) composition of frozen palm insolid soils, %.

| Location                | Horizon | Depth, cm | Loss from HCL, a % | Diameter of fractions, mm | Sum of particles | Factor degree of structure |
|-------------------------|---------|-----------|--------------------|---------------------------|-----------------|---------------------------|
|                         |         |           | 0.25 - 0.05        | 0.05 - 0.01               | 0.005 - 0.001   | <0.01                     |
|                         |         |           | 1-                 |                           |                 |                           |
| Larch forest            | A2 b    | 10-20     | 8.4                | 27.8                      | 42.6            | 4.9                       | 8.0                       | 6.8                       | 19.7                      | 15                        | 12                        |
| cowberry (pl.1)         | B1      | 20-30     | 11.1               | 29.4                      | 44.9            | 6.4                       | 7.2                       | 1.0                       | 14.6                      | -                         | -                         |
|                         | B ca    | 35-70     | 4.8                | 32.6                      | 50.7            | 8.4                       | 2.0                       | 1.5                       | 11.9                      | -                         | -                         |
|                         | C1      | 70-90     | 27.7               | 34.3                      | 29.8            | 3.1                       | 3.0                       | 2.1                       | 8.2                       | -                         | -                         |
|                         | C2      | 90-120    | 17.8               | 42.7                      | 25.7            | 1.8                       | 4.6                       | 5.9                       | 12.3                      | 36                       | 18                       |
| Larch forest            | A2      | 10-20     | 33.3               | 55.9                      | 5.5             | 0.3                       | 0.4                       | 4.1                       | 4.8                       | -                         | -                         |
| without grass           | B1      | 20-35     | 36.1               | 42.7                      | 25.7            | 1.8                       | 4.6                       | 5.9                       | 12.3                      | 36                       | 19                       |
| vegetation (pl.2)       | B ca    | 35-62     | 27.7               | 34.3                      | 29.8            | 3.1                       | 3.0                       | 2.1                       | 8.2                       | -                         | -                         |
|                         | C1      | 62-90     | 11.5               | 33.6                      | 40.9            | 5.3                       | 5.8                       | 2.9                       | 14.0                      | -                         | -                         |
|                         | C2      | 90-140    | 17.6               | 42.7                      | 25.7            | 1.8                       | 4.6                       | 5.9                       | 12.3                      | 36                       | 19                       |

*HCL-10% hydrochloric acid solution to determine carbonates in soil.

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