Methods for Preserving Biodiversity of Meadow Steppes in the Middle Lena Valley

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Abstract. This article considers the results of the studies of the Agricultural and Ecological Group 6 lands of the Nam agricultural landscape conducted in the lower Lena valley under various nutrition regimens in natural steppificated meadows with content of steppe grasses of up to 52%. We established that steppe grasses react differently to fertilizers. Using various dosages of mineral and organic fertilizers helped increase the share of couch grass up to 74-93% while maintaining the share of steppe bluegrass at 14%, along with the mixed herbs including creeping sage at 24%. The combined use of organic and mineral fertilizers helps preserve steppe grasses, especially couch grass, up to 93% while preserving the steppe bluegrass up to 12% and mixed herbs up to 24%, which facilitates the hay fodder yield of up to 20 dt/ha.

1. Introduction
Central Yakutia is home to 51% of the population of the Republic of Sakha (Yakutia). It also houses 70% of the cattle stock, 45% of horses, and 40% of pigs. Low productivity lands that are not fit for haymaking are used for haphazard pasture and aftergrowth pastures. These lands include meadow steppes located in the middle Lena valley. These meadow pastures are deemed remote and difficult to develop agriculture and crop farming due to the arid summers and low fertility of cryomorphic floodplain soils and the remoteness of water supply sources.

2. Relevance and novelty
The key meadow steppe plots are located in Central Yakutia. These are steppificated meadow pastures. The grass cover of steppificated meadows is mainly formed under the intensive early spring pasturing under insufficient moisturing. Meadow plant communities usually feature at least 40-50 plant species. In dry years, the grass stand is thinned and the projective cover is up to 50-70%. Due to the low productivity (3-4 dt/ha of hay on average), steppificated meadows are mainly used as early spring and winter pastures for horses’ winter grazing. The plant biodiversity of the meadow steppes of Yakutia has been studied extensively, yet there are still no developed methods of preserving and improving low-productivity steppificated meadow pastures through the improvement of nutrition regimen.
3. Statement of problem
The purpose of the study is the development of methods to preserve meadow steppe mixed herb and grass composition based on the improvement of nutrition regimen using organic and mineral fertilizers. The key objective of this work is to determine the reactions of natural steppe species to organic and mineral fertilizers, as well as the impact of organic and mineral fertilizers on the preservation of steppe grasses.

4. Theory
The meadow steppes of Yakutia feature unique extra zonal vegetation. The first description of tyr feather grass in Yakutia was provided by A.K. Kayander in 1903. The steppes of Central Yakutia were described by R.I. Abol in (1929), G.I. Dolenko (1913), B.N. Gorodkov (1938), etc. The extensive research by T.A. Rabotnov in southern and central districts of Yakutia proved that the plant life in the steppes of Central Yakutia has a lot in common with the steppes of Cisbaikalia and Northern Transbaikalia [19,20,21,22,23]. The classification of Yakutian steppes was based on the procedures suggested by E.M. Lavrenko (1940) in his monograph on the Key Features of the Vegetation Cover of Yakut ASSR. The origin of the meadow steppes of Central Yakutia is linked to the history of the vegetation cover development (steppe vegetation is a relic one, preserved from the interglacial xerothermic periods), as well as the cryomorphic and arid character of the climate. The steppes of Central Yakutia have the same origin and floristic composition as the steppes of Cisbaikalia and Transbaikal-Mongol steppes [3,5,6,7,14]. Further research by phytogeographers confirmed that the meadow steppes of Yakutia have common features with Cisbaikal and Transbaikal-Mongol steppes. They have the same origin and floristic composition as the latter ones [9].

According to the phytogeographical zoning, meadow steppes belong to the Central Yakutian floristic zone comprising about 1026 species of higher vascular plants. The steppificated meadows of the Central Yakutian floristic zones are attached to well-drained ridges in the floodplains with sod-meadow sandy-loam soils. Their appearance in the alluvium of the river Lena is due to the fact that in cold climates sandy soils are drier and warmer. Steppificated meadows turn into steppes on the terraces above the flood plains due to insufficient moisture and high summer temperatures. Steppificated meadows of the middle Lena valley are represented by cespitose-grass-forb meadow steppes, as well as grass or grass-vermouth steppe [8]. Steppe communities are formed on unforested slopes of valley walls where the melting of the ground in spring and early summer is fast and deep, which results in the constant lack of soil moisture during the vegetation period. There are different types of steppes including meadow, true, desert, and petrophytous varieties. The flora of the steppificated meadows has a rich species composition. The environmental conditions of the steppificated meadows are halfway between the true meadows to steppes. Their grass stands always features steppe plants [18]. The steppe vegetation of the middle Lena valley is a unique natural phenomenon that has been attracting researchers for many years. It features numerous species of grass, sedge, legume, aster, ranunculaceous, and rose families. The most widespread plant in spring is the yellow eastern pasque flower that colors the entire steppe in lemon-yellow in early June [11,12,16].

Currently, the isolation of meadow steppes from the haphazard pasturing in pasture ecosystems results in the convergence of plant composition with the drained lake meadows featuring higher shares of mesophyte grasses [4]. Here, steppe areas experience a strong anthropogenic impact due to economic activities like ranching and settlement. Under such conditions, relic plant species become critically endangered [10, 24].

It is impossible to improve the growth and development of meadow grasses without the improvement of the nutrition regimen. Fertilizers are one of the key factors for the nutrition of meadow phytocoenoses. Numerous experiments during the intensification of applied meadow cultivation in the cryolithic zone prove that the grass stand of northern meadows has the same response to mineral fertilizers as the meadows in other regions with more favorable conditions for grass growing [1,2,15, 25, 26, 27]. In the cryomorphic soils of Yakutia, all of the fertilizer functions (trophic, regulatory, and reclamation) become stronger. The trophic function of fertilizers is
complicated by the suppressed root absorption due to the weaker physiological activity of the roots. Besides, cryomorphic soils have smaller amounts of mineralizer bacteria. Thus, the mobilization of active forms of fertilizer elements has a lower intensity and depends on the availability of heat to the soils [13]. Mineral and organic fertilizers have a great impact on the species composition and the yields of hay fodder depending on the availability of water during vegetation periods. Mineral fertilizers affect the quality of fodder by changing the floristic composition and morphological structure of specific plant species with different biochemical compositions.

Improved floristic composition is a key factor determining the response of natural steppe species to organic and mineral fertilizers. Economically valuable groups and species of meadow steppe grasses that can take nutrients from fertilizers and soil at a high rate have an advantage over other constituents of the meadow plant community.

The floristic composition of a mixed herb/grass community of the reference sample (without fertilizers) was dominated by wild grasses (up to 77.5%), especially couch grass (Elytrigia repens) up to 37.0% and steppe bluegrass (Poa stepposa (Krylov)Roshev.) up to 20.6% (Figure 1). The dominant legume species was the strobilaceous oxytrope (Oxytropis strobilacea Bunge.) with a share of up to 9.1% in the floristic composition. The mixed herbs included the perennial flax (Linum perène), multicolored dianthus (Dianthus versicolor), sow thistle (Sónchus arvénsis), and snowdrop anemone (Anemóne sylvéstris). The herbage was dominated by vicarian sage (Artemisia commutata Bess.) taking up to 7.3% of the grass stand.

![Floristic composition of mixed herb/grass community under organic and mineral fertilizers](image)

Figure 1. The floristic composition of mixed herb/grass community under organic and mineral fertilizers in % of the grass stand

1. Reference - no fertilizers
2. Mold, 20 t/ha, once in 4 years
3. Mold, 20 t/ha, once in 4 years + N_{60}P_{60}K_{60} every year;
4. N_{60}P_{60}K_{60} every year;
5. N_{30}P_{30}K_{30} every year;
6. Mold, 20 t/ha, every year;

The vegetation periods under research (2013-2016) were characterized by more-than-average moisturizing, which helped preserve legume species in the mixed herb/grass community. The
reference sample that had no fertilizers was dominated by grass species (up to 52.8% of the grass stand), including couch grass (Elytrigia repens (L.) Nevski.) up to 38.5% and steppe bluegrass (Poa stepposa (Krylov)Roshev.) up to 11.5% of the grass stand. Due to the humid vegetation periods (hydrothermal index of 0.90-0.80), the content of legumes in the grass stand approached 21.2%, mostly strobilaceous oxytropes (Oxytropis strobilacea Bunge.) with a share of up to 18.9% of the grass stand. The share of mixed herbs in the grass stand was about 26%.

Under humid conditions, mixed herb and grass community was preserved depending on the fertilizers applied, and the grass stand was dominated by steppe grasses.

Under relatively favorable water availability and organic fertilizers, the content of wild steppe grasses increased up to 50.7-73.7% of the grass stand, and legumes up to 30.5-2.1%. Organic fertilizers helped transform the mixed-herb/grass community into a grass/mixed herb one. The response of steppe grasses to the annual application of mold at a rate of 20 t/ha was high. Their content in the grass stand increased up to 73.7%, which is 20.9% above the reference value. The highest response to organic fertilizers was observed with couch grass (up to 60% of the grass stand), which was 21.5% higher than the reference value. At the same time, the share of steppe bluegrass decreased to 5.7% of the grass stand, which is 5.8% lower than the reference value. The annual application of mold at a rate of 20 t/ha helped preserve the mixed herbs in the mixed-herb/grass community at a level of 24.2% of the grass stand due to the presence of vicarian sage (up to 20.5% of the grass stand).

Under a combination of organic and mineral fertilizers (mold at a rate of 20 t/ha once in 4 years + N₆₀P₆₀K₆₀ annually), the share of steppe grasses increased significantly up to 87.2% of the grass stand which is 34.4% higher than the reference value. The share of mixed herbs in the plant community decreased to 12.8% of the grass stand, which is 13.2% lower than the reference value. In general, the combination of organic and mineral fertilizers for the mixed-herb/grass community helped increase and preserve the share of steppe species in the grass stand, especially the couch grass (up to 74.3% of the grass stand).

Mineral fertilizers (applying various doses of N₆₀P₆₀K₆₀ and N₃₀P₃₀K₃₀ to mixed-herb/grass community) preserved the share of steppe grasses at 71.0-74.4% of the grass stand with the dominance of couch grass up to 60.4-51.2% of the grass stand. We must note that the high competitive power and nitrophilous nature of couch grass made the presence of other wild grasses remain at the same level, e.g. steppe bluegrass comprised up to 11.5-12.4% of the grass stand. Due to the sufficient availability of water and the nutrition regimen, the share of mixed herbs in the phytocoenosis also remained at 21.1-29.0% of the grass stand, mainly due to the reduction of the share of legumes to 1.5% of the grass stand.

5. Applicability
Various organic and mineral fertilization regimens can be used to preserve the plant biodiversity in the meadow steppes in the middle Lena valley. The combined use of organic and mineral fertilizers increases the preservation of wild steppe grasses up to 74%, which is 22% higher than in the no-fertilizer sample and statistically significant. We established that steppe grasses react differently to fertilizers. The steppe edificatory plant, couch grass, has a high response rate to the application of mineral and organomineral fertilizers (up to 60-74%). At the same time, the share of steppe bluegrass reduced by 12% after the application of fertilizers, while the mixed herbs remained at 21% irrespective of the different nutrition regimens.

6. Conclusions
Thus, the reaction of mixed-herb/grass phytocoenosis to various nutrition regimens depended on the degree of moisturizing during vegetation periods and fertilizers used. During more arid periods, the impact of mineral fertilizers was more significant. It helped preserve wild grasses in the grass stand at a share of 93%. Under more humid conditions, the preservation of grasses and legumes was significantly higher when organomineral and organic fertilizers were used. Overall, the improved nutrition of mixed-herb/grass steppe meadow helps preserve steppe grasses as a valuable floristic
group and promotes the transformation of natural grass stands with more economically valuable communities to facilitate fodder production in the lands of Agricultural and Ecological Group 6 in the Man agricultural landscape.

7. References

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