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Structure of vegetation and phytomass and mortmass stocks in Mongun-Taiga mountain tundra-steppe ecosystems

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Abstract. The species composition and quantitative indicators of fractions aboveground and underground phytomass and mortmass of tundra-steppe ecosystems of the northern macroslope of the Mongun-Taiga Mountain. Steppe communities are submitted to such mountain-steppe species as *Koeleria altaica*, *Bupleurum multinerve*, *Carex ediformis*, *Festuca kryloviana*, *Potentilla sericea*, *Artemisia commutata*, *Aster alpinus*. Tundra formations are high-mountain meadow and tundra species *Astragalus adsurgens, Oxytropis intermedia, Stellaria petraea, Festuca altaica u Artemisia frigida.* The total stock of plant matter and the main stock of green phytomass are formed by the types of dominants, such as *Oxytropis intermedia, Carex rupestris u Festuca altaica.* The ecological interpretation of the values of species composition in the formation of stocks of plant matter and the features of the functioning of tundra-steppe ecosystems is presented on the basis of established values of the ratio of aboveground and underground phytomass and mortmass fractions.

1. Introduction

In the system of altitudinal differentiation of the highland belt of the arid mountains, a special sub-belt of cryophilic steppes is distinguished, within which forest vegetation partially or completely falls out, which results in direct contact of mountain steppes with high-mountain communities [1]. In the literature there are significant generalizations on the geography and phytocenology of tundra-steppe ecosystems, but their biological productivity and the features of the production process are extremely poorly researched. At the same time the vegetation cover in the system of ecological and geographical analysis occupies a central place, as it is an integral indicator of the functioning of ecosystems, an indicator of the spatial organization of the landscape and serves as a basis for creating thematic layers of soil and vegetation cover from data indicative interpretation of space images. The quantitative indices of the stocks of plant matter are necessary both for understanding the functioning of tundra-steppe ecosystems and for estimating their productive potential. In the studied tundra-steppe ecosystems, the formation of fractions of plant matter is determined by the percentage of participation of certain plant species. According to the data received, the total stock of plant matter and the main stock of green phytomass is formed by species of dominants, such as *Astragalus adsurgens, Oxytropis intermedia, Stellaria petraea, Festuca altaica* and *Artemisia frigida.* In the formation stocks of underground phytomass and mortmass, the contribution of dominant species differs significantly from the composition of dominants forming the aboveground part of the stocks of vegetation matter.

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Despite the fact that the contribution of individual species in the formation of vegetation stocks is insignificant, they also have an independent ecological significance.

2. Objects and methods

The key study sites with the most common types of the tundra-steppe complexes were selected on the northern macroslope of the Mongun-Taiga Mountain range according to the altitude gradient principle in geomorphologic classification and the general concept of a catena [2]. Katena, encompassing the periglacial landscapes of the highland massif, was laid along the valley of the Right Mugur River, including its glacial part, taking into account the location of the model polygons of long-term studies of dynamic and evolutionary changes in high-mountain geosystems performed by the team of the Physical Geography and Landscape Planning of St. Petersburg State University. The total length of the catena from the eluvial to the trans-accumulative positions is more than 600 m, the slope of the slope is 25-30 °. Specific soil-forming processes in the tundra-steppe complexes of the Mongun-Taiga Mountain range resulted in the formation of soil cover structural units where mountain tundra soil immediately neighboured with steppe-type soils. The main regularities in the formation of vegetation cover productivity in key sites of tundra-steppe ecosystems were obtained using the methods described by A A Titlyanova [3]. To estimation the productivity of tundra-steppe ecosystems, steppes, was made determination of the stocks of living phytomass, which represent the mass of living aboveground and underground vegetation per unit area, according to the data at the time of determination; stocks of mortmass that represent the mass of dead aboveground and underground plant organs per unit area, according to the data at the time of determination and the structure of the vegetation matter, which includes the stocks of all components of plant matter and the ratio of these stocks. The working moments of the field definitions vegetation productivity are presented in the figure 1.

Figure 1. Sampling of soils and vegetation matter for study the stocks and structure of the aboveground and underground phytomass and the mortmass of tundra-steppe vegetation of the Altai-Sayan region.

3. Results and discussion

The ecological specificity of the impact of the Eastern Mugur glacier, which occupies a significant part of the total area of glaciation, is manifested at all hypsometric levels of the catenary complex. A particularly high intensity of the effect of the dynamic phenomena of glaciation on the formation and functioning of soil and vegetation cover is noted at the position of El catena, which is in the immediate vicinity of the glacier tongue at an altitude of 2,741 m. Severe climatic conditions and steep slopes of erosion-denudation relief impede the continuous development of vegetation and soil cover. On small areas among rocky outcrops and placers of stony rocks under sparse vegetation of cobresia and alpine grasses primitive mountain-tundra soils are formed, which are poorly differentiated into genetic horizons, characterized by a low content of organic matter and a high degree of detritus. In the middle part of the catena at an altitude of 2,661 m under the grass and shrub vegetation, mountain-tundra turf soils form and in the accumulative position of the catena at an altitude of 2,644 m, mountain tundra gley soils form under rather large contours of tundra-meadow vegetation. Main factors of the species composition and reserves of aboveground phytomass and mortams are presented in table 1.

Table 1. Species composition and stock of aboveground phytomass and mortams

№	Species composition	Stock of vegetation matter fractions		
		%		g/m^2
		of total stock	from green phytomass	
1	*Astragalus adsurgens*	10,0	4,8	25,90
2	*Oxytropis intermedia*	13,3	6,4	34,50
3	*Oxytropis altaica*	20,9	10,0	54,25
4	*Carex rupestris*	7,9	3,8	20,46
5	*Artemisia frigida*	10,6	5,1	27,46
6	*Artemisia rupestris*	4,3	2,1	11,23
7	*Stellaria petraea*	21,0	10,1	54,63
8	*Androsace bungeana*	6,1	3,0	16,04
9	*Potentilla astragalifolia*	1,2	0,6	2,96
10	*Poa alpina*	4,7	2,3	12,15
11	*Kobresia capilliformis*	0,1	0,0	0,21
12	*Eremogone formosa*	4,9	2,3	12,69
13	*Festuca altaica*	10,3	4,9	26,69
14	*Silene turgida*	2,1	1,0	5,38
15	*Saxifraga spinulosa*	0,7	0,4	1,88
16	*Parmelia sp.*	0,4	0,2	1,00
17	*Seseli condensatum*	0,7	0,3	1,71
18	*Draba altaica*	0,8	0,4	2,19
19	Разнотравье	0,2	0,1	0,38
20	*Aster alpinus*	0,2	0,1	0,38
21	*Helictotrichon hookeri*	0,9	0,4	2,42
Green phytomass				260,21
Perennial living phytomass				54,25
Rags (D)				106,04
Litter (L)				120,75
Aboveground mortamass				226,79
The total stock of phytomass and mortmass				541,25

In the formation of aboveground phytomass, both species that are characteristic of petrous and humidified habitats, and typically steppe species take part. The main stock of green phytomass and the total stock of vegetation matter is formed by species of dominants such as *Stellaria petraea, Oxytropis* *altaica, Oxytropis intermedia, Festuca altaica, Astragalus adsurgens,* and *Artemisia frigida*. In sum, their contribution to the total stock of phytomass is more than 70% and more than 40% in the stock of green phytomass. In the formation of underground phytomass and mortamass stocks the contribution of dominant species differs significantly from the composition of dominants forming the aboveground part of the stocks of vegetation matter. The dominant species forming the main stock of total, living and dead roots are *Oxytropis intermedia, Carex rupestris Festuca altaica, Poa alpina, Artemisia frigida* (Table 2). The total stock of underground phytomass and mortmass almost three times higher, than the stock of phytomass and mortmass of aboveground vegetation substance. Ratio of green phytomass and living roots constitute 2.7 and living roots and dead roots is 0.77, which also closely corresponds to the values obtained for the steppe zone of Siberia.

In the future, an ecological interpretation of the significance of the species composition in the formation of plant matter stocks and the features of the functioning of tundra-steppe ecosystems will be presented based on the established values of the ratio of the aboveground and underground phytomass fractions and the mortmass.

Table 2. Species composition and stock of underground phytomass and mortams

№	Species composition and fractions underground phytomass and mortams	Stock of vegetation matter fractions			
		% from root stock			g/m^2
		total stock	living roots	dead roots	
	Living roots (R) fractions > 2.0 мм				
1	*Oxytropis intermedia*	17,4	15,4	11,8	230,67
2	*Carex rupestris*	4,7	4,2	3,2	62,33
3	*Festuca altaica*	5,2	4,6	3,6	69,33
4	*Poa alpina*	2,4	2,1	1,6	32,00
6	*Androsace bungeana*	0,5	0,4	0,3	6,67
7	*Stellaria petraea*	0,3	0,3	0,2	4,00
8	*Artemisia frigida*	2,8	2,4	1,9	36,67
10	Mildew	3,1	2,7	2,1	41,00
11	Other roots	7,9	7,0	5,4	105,33
	Living roots (R) fractions 2.0 - 0.5 мм				323,00
	Living roots (R) fractions < 0.5 мм				412,83
	Tillering nodes of *Carex rupestris*				59,67
	Rhizomes of *Carex rupestris*				3,33
	Tillering nodes of *Poa alpina*				10,67
	Rhizomes of *Poa alpina*				3,00
	Tillering nodes of *Festuca altaica*				98,00
	Dead roots (V)				
	Fractions > 2.0 мм				713,00
	Fractions 2.0 - 0.5 мм				801,00
	Fractions < 0.5 мм				437,33
	Total roots R				1327,17
	Total tillering nodes				168,33
	Total underground phytomass				1501,83
	Total underground mortams				1951,33

4. Conclusion

Characteristic parameters of the structure of vegetation matter, which are used to estimation the functioning of ecosystems, are the ratios of their fractional composition. In the ecosystems studied, the ratio G / (D + L), which reflects the ratio of the rates of formation of aboveground phytomass and its death is 1.15, and the ratio R / V reflecting the rates of formation, death and decomposition of underground organs is 0.77, which fairly closely corresponds to the values of the ratio of the fractions of the aboveground and underground phytomass and mortmass in the steppes of Central Siberia.

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