Mosses in Pine Phytocenosis in Dry Climate of East Kazakhstan

Irina Pankiv[1], Svetlana Nesterova[2], Nurziya Karipbayeva[3], Vassiliy Polevik[4], Viktor Khromov[5]

[1]Shakarim State University of Semey
Semey, Kazakhstan

[2]Al-Farabi Kazakh National University
Almaty, Kazakhstan

[3]Shakarim State University of Semey
Semey, Kazakhstan

[4]Shakarim State University of Semey
Semey, Kazakhstan

[5]Shakarim State University of Semey
Semey, Kazakhstan

**Corresponding author's email: irina.g.pankiv [AT] gmail.com*

ABSTRACT— ***The present article is concerned with the results of a long-term study on the role of bryophytes in pine phytocenosis of East Kazakhstan. Comparative studies have been conducted in order to identify the change of species composition and their frequency on dry, fresh and wet formations of pine forest, as well as on the sites recovering from forest fires of 1997-2005. Such a large-scale study on the role of mosses with the use of geobotanical approach is the first to have been carried out in the territory of the Republic of Kazakhstan. The results of the study have provided data on species diversity of mosses in pine forest, their role in phytocenosis and an activity level of every specie in synusiae. Depending on the change of key parameters of plant communities in pine forest principles of bryophyte expansion have been identified.***

Keywords— Bryophytes, mosses, species diversity, pine forest, plant community, distribution, Semey city, East Kazakhstan, synusiae, geobotanical approach, Drude's scale, level of species activity.

1. INTRODUCTION

Kazakhstan is one of the largest countries in Asia, with an area of 2,724,900 square kilometers. Apart from the distribution data given on a country basis for the whole area of East Europe and North Asia [10, p. 2], no bryophyte checklist of such a wide area has, however, been published yet, and the bryophyte flora of large parts of the territory has never been surveyed. This is the case for the bryophyte flora of the area around the city of Semey (Eastern Kazakhstan).

Mosses are the least studied plant group in Kazakhstan and are not mentioned in "Flora of Kazakhstan" multivolume reference book [24]. Considering the gap in the database of flora of Kazakhstan, the studies in this field may provide solutions to the problem.

Research on species diversity of mosses and their distribution in the territory of Semey ecological region will make a considerable contribution to the database of Kazakhstan biodiversity within the framework of the Convention on Biological Diversity (Rio De Janeiro, 1992). The recognition and the definition of the role of mosses in ecosystem activity is considered to be an important scientific mission in the field of environmental protection, as well.

Among higher plants mosses are the oldest and the most poorly studied plant groups in the world with Kazakhstan not being an exception. There are no sufficient data on species diversity, distribution and ecology of bryophytes in Kazakhstan. This fact witnesses to a considerable gap in the data on flora of Kazakhstan.

No data on the role of bryophytes in plant community composition in the territory of the Republic of Kazakhstan have been accumulated. There is also an obvious lack of bryologists who could specialize in this field of research.

The findings of the field research data on species diversity and fundamental biological and ecological features of moss can be used as the fundamental basis of the development of the system under consideration bioindicative control areas in the organism (through specific species of moss), population and ecosystem levels, taking into account the already

studied Physics and local geographical and ecological features. This area seems to be very relevant to the scientific-theoretical and practical positions. Reliability bioindicative studies using moss can significantly improve the current system of state ecological control areas under surveillance to a new level of performance and environmental research of statistical information.

2. MATERIALS AND METHODS

Bryophytes species have been identified according to a number of reference books [7, 11, 12, 25], by means of the comparative anatomical-morphological method.

Exsiccatae of higher tracheophytes have been collected and processed according to the guidelines defined by A.K.Skvortsov [28, p.18-27]. Species identification has been performed by means of the comparative anatomical-morphological method with the use of a number of reference books, such as: "Illustrated Guide on Plants of Kazakhstan" [9], "Flora of Kazakhstan" [24].

Exsiccatae have been collected and processed by means of A.K.Skvortsov's method that is considered to be common and widely used [27].

Flora cadastre has been compiled according to the generally accepted A.Engler's system. S.K.Cherepanov's summary reports have been applied in order to clarify the names of genus and the plants species [4].

Geobotanical description of phytocenosis and moss presence therein has been made on temporary sample plots of 50 square meters in size according to standard techniques.

Abundance ratio has been identified by means of Drude's scale linked to the percentage cover scale:

- soc (socialis) – "copious", plants close their aerial parts forming pure thicket (nearly or fully); in this case other species can be seldom or never found, or be found individually. Plant cover is from 80 to 100%;
- cop3 (copiosus) – "a great many", there are multiple plants creating a "background"; plant cover is from 20 to 80%;
- cop2 – "many", plants are found in large quantities and often locally; general plant cover is 4 to 20%;
- cop1 – "quite many", plants are found occasionally and distantly; plant cover is from 0.8 to 4% ;
- sp (sparsus) – "few", plants are hardly found; plant cover is 0.16 to 0.8%;
- sol (solitarius) – "one", there are very few plants; only a few isolated plants per a sample plot. Plant cover level is very low, up to 0.16% [1, 16, p. 64-66].

Abundance and frequency of occurrence of bryophytes in synusiae have been defined as "species activity". This frequency index has also been applied by A.A.Shestakova to describe eco-coenotic features of bryobiota of Nizhny Novgorod region in the Russian Federation [26, p. 7-13].

The key points of detailed geobotanical study have been registered by a GPS device.

2.1 Study area

The area of Semey (50°26′W 80°16′E) is characterized by cold and dry continental climate.

2.2 Landform

Modern landform (relief) of pine forests is rather complicated. Its origin is associated with alluvial and aeolian processes. The landform structure mainly consists of the following distinct forms:

- the most irregular alluvial-accumulative forms with aeolian surface processing represented by high hummocky ridges of sand massifs; they shape the main landform background of pine forests;
- meadow-steppe, lowland plots located in spots and strips among hummocky sands;
- alluvial-erosional landforms represented by the zones of ancient erosion with alluvial river and lake terraces and lake basins;
- aeolian landforms represented by islands or strips that rise above meadow-steppe lowland landform elements up to 40 m high. As a rule, their long central line is directed towards pine forest strips.

Soil cover of pine forests is formed in dry continental climate, with different level of ground waters, and on loose fine-grained and average-grained outwash and predominantly quartz sands.

2.3 Climate

The climate is rather severe for the growth of biocenosis. During summer time evaporative capacity is much higher than precipitation depth. This fact explains dry climate conditions of the studied area. Dry and windy weather with frequent dust storms burns soil and dehydrates plants splashing them with soil particles.

Climatic conditions of East Kazakhstan region are characterized by a transition from moderate to extreme continental climate with hot summers (up to +430C) and frosty winters. Winter season lasts for about 5 months (from November to March) with January being the coldest. Average temperatures in January in the Irtysh river region and in piedmont plains are from -170C to -220C, on mountain slopes – from -150C to -170C, in mountain trenches – down to -270C. During the prevalence of northern winds in January and February atmospheric temperature can go down to -430C and very rarely to -550C in some areas (January-February, 2001). Average wind speed in winter is 2.5-3.5 m/sec. Average depth of soil freezing ranges from 50 to 120 cm, and rarely during dry and frosty winters it can increase to 140 cm [6].

Spring season is very short and lasts for approximately 1.5 to 2 months. At the end of April the weather is already warm and sometimes hot. However, during this period there may be considerable fluctuations of diurnal temperatures, frequent drops in temperature and strong winds [6].

In the territory of East Kazakhstan summer season lasts for 3 months where July is the hottest. Average temperatures during summer season in Irtysh river region and in the territory of hummocks are from +18 to +230C (at noon – from +24 to +260C). Maximum temperature can reach up to +430C. During summer season warm and dry continental-moderate air masses predominate making the weather hot, clear and calm. The fall of temperature at night often causes dew formation [6].

Average annual precipitation level is 200-280 mm in the territory of steppe zone in the Irtysh river region [6].

2.4 Hydrology

Hydrographic network in pine forests is poorly developed. The main river in Semipalatinsk region is the Irtysh which is the main left-bank tributary of the Ob river. The depth of the river is 2-4 m, during high-water season it goes up to 6-9 m. The right bank of the Irtysh river does not have a river system [6].

2.5 Data collection

The study on vegetation cover of pine forest in Semey region was carried out on an annual basis from June to September during a five-year-period (2010-2014).

The total number of days spent in expedition is 138.

2.6 Statistical analysis

Data analysis has been done with the use of Microsoft Office Excel 2013 data analysis application.

3. LITERATURE REVIEW

The research of the role of mosses in phytocenosis is considered in the works of many scientists.

It is important to research not merely the species composition of plants and bryophytes, but their role in phytocenosis, as well. Species composition and distribution of the mosses and vascular plants, varies in different latitudes. The study has shown that moisture-loving mosses and vascular plants have a higher level of local frequency compared to their frequency regionally [5, p.161-162].

Bryophytes are often the dominant components of the boreal flora. They are able to perform many diverse functions in the ecosystem. However, their species diversity is usually insufficiently perceived. [18, p.170-172]

Mosses may generate a negative impact on the growth and development of other plants in the community. They may affect the absorption of plant nutrients and have a negative impact on the root system and nitrogen (N) uptake. [2, p.1-5] According to some data accumulated in the boreal forest area, mosses are able to increase nitrogen level in the soil fixing cyanobacteria [19, p.2022-2026; 22, p.154-159].

An important feature of the moss cover is its ability to regulate temperature and moisture of the soil [29, p.1442-1444]. The appearance of water-loving mosses and the change in soil water balance lead to changes in the carbon balance and eventually to the replacement of one plant community by another [23, p.807-810].

Sphagnum mosses increase the level of water table treatment. In this case, the change of water regime may indicate

global changes in phytocenosis. Usually it shows the evidence of waterlogging of the area, changes in phytocenosis, as well as climate changes [20, p.277-280].

The results show that changes in the composition of peat swamps phytocenosis most likely indicate future climate change and demonstrate the gradual dominance of graminoid species composition of fens [3, p.388-390].

Brown mosses have long predominated in lowland swamps. However, with the change of environmental conditions they may quickly turn into sphagnum [8, p.3047-3048; 17, p.10-12; 31].

Climate changes have occurred quite rapidly, especially recently [13]. Bryophytes can be very sensitive to environmental changes [22. P.154-156; 30, p.163-165]. This fact may be especially important for long-term studies of mosses and lichens with the situation assessment purposes [14, p.1-2]. The scientists have been investigating the role of Sphagnum and Pleurozium mosses in the composition of tundra phytocenosis during 5 years. The researchers have noted the important role of these types of mosses on what is occurring in the ecosystem and especially below ground [15, p. 1070-1072]. In the early stages of research it is important not only to study moss species composition, but also to assess habitat conditions, which is of greater importance in the study of ecological groups of mosses in the vegetation community composition [21, p. 110-113].

Bryophytes are quite abundant in boreal forests, so the change in the composition of moss communities can have serious implications for various processes in the whole ecosystem resulting from changes in the conditions of moisture, nutrition, and other environmental features [22, p.154-156].

4. RESULTS

As a result of the study 33 moss species have been identified in the territory of the pine forest: 1livewort (*Marchantia polymorpha*), 1 sphagnum moss (*Sphagnum squarrosum*) and 31 leafy mosses.

After fires of 1997-2005 the territory of the pine forest was divided into phytocenosis of secondary succession and territories of green forest untouched by fire.

Plant cover on burned areas showed both steppe and forest grass species: *Carex supina, Festuca sulcata, Stipa pennata, Stipa capillata, Pulsatilla patens, Achillea millefolium, Equisetum hiemale, Chenopodioum acuminatum, Senecio jacobea, Phleum pleoides, Medicago falcata, Artemisia frigida, Centaurea scabiosa, Helichrysum arenarium, Artemisia austriaca, Erigeron acris, Gypsophila paniculata, Dianthus uralensis, Linaria vulgaris*, etc.

Tree layer is thinned and is found as rather dense groups or strips. The level of crown density compared to the whole area is very low (about 10-15%). Here, *Pinus sylvestris* and *Populus tremula* dominate, and *Betula pendula* is found not as often. *Spirea hypericifolia* is a widely spread representative of shrubs. In total plant cover amounts to 60% on the average, where mosses represent 2-8%. The following moss species are found in the studied area: *Polytrichum piliferum, Ceratodon purpureus, Syntrichia ruralis, Bryum argenteum,* more rarely - *Polytrichum juniperinum* and *Ptychostomum boreale*. There are 6 species that make 18.2% of all the species diversity of mosses in pine forest. Here, the most active moss species are *Bryum argenteum, Ceratodon purpureus* and *Polytrichum piliferum*.

In the studied area synusiae of ground mosses predominate. Moreover, *Bryum argenteum, Ceratodon purpureus* have been discovered on burned wood.

The scientists were able to mark 14 sample plots in the territory of green pine forest where species diversity of plants and projective cover (%) were identified.

Dry pine-sedge forests are spread in the west and, especially, in the north-west. In these territories plots no. 9, 10, 11 and 14 have been marked (Tab. 1).

Table 1: Share of mosses in plant communities of dry pine forests

Plot, 20 sq.m.		Vegetation cover					
			Higher tracheophytes		Mosses		
No	**Coordinates and altitude above sea level**	**Projective cover (%)**	**Species**	**Abundance**	**Moss share (%)**	**Moss species**	**Species activity level**
9	50^0 44’ 9’’N 79^0 49’ 50’’E 229 m	65	*Pinus silvestris var. kulundensis*	Cop.2	0,5	*Bryum argenteum*	Inactive
			Carex stenophylla	Cop.2		*Polytrichum piliferum*	Inactive
			Festuca sulcata	Cop.2			
			Artemisia austrica	Cop.1			
			Artemisia scoparia	Cop.1			
			Phleum phleoides	Sp.			
			Stipa capillata	Cop.1			
10	50^0 46’ 16’’N 79^0 43’ 03’’E 236 m	65	*Pinus silvestris var. kulundensis*	Cop.2	0,1	*Bryum argenteum*	Inactive
			Carex stenophylla	Cop.2			
			Festuca sulcata	Cop.2			
			Helichrysum arenarium	Cop.1			
			Artemisia austrica	Cop.1			
			Gypsophilla paniculata	Sp.			
			Pulsatilla multifida	Cop.1			
11	50^0 41’ 51’’N 79^0 21’ 26’’E 247 m	60	*Pinus silvestris var. kulundensis*	Cop.2	0,8	*Bryum argenteum*	Less active
			Carex stenophylla	Cop.2		*Ceratodon purpureus*	Inactive
			Festuca sulcata	Cop.2			
			Helichrysum arenarium	Cop.1			
			Spirea hypericifolia	Sp.			
			Pulsatilla multifida	Sp.			
			Artemisia austrica	Cop.1			
14	50^0 38’ 02’’N 79^0 31’ 46’’E 247 m	65	*Pinus silvestris var. kulundensis*	Cop.2	0	-	-
			Carex stenophylla	Cop.3			
			Festuca sulcata	Cop.1			
			Spirea hypericifolia	Sol.			
			Gypsophilla paniculata	Sp.			
			Artemisia scoparia	Cop.1			
			Artemisia austrica	Cop.1			
Total mean value of cover (%)		64			0,35		

The above mentioned territories did not suffer from forest fires; mean value of projective cover is 64%. Tree layer consists of common pine (*Pinus silvestris var. kulundensis*). Shrub layer is presented only by thinned groups of *Spirea hypericifolia*. Tree crown density amounts to about 40%. Field layer of dry pine forest is mainly formed by *Carex stenophylla, Festuca sulcata* and by *Artemisia* genus species. The share of bryophytes in this phytocenosis is insignificant and averages at 0.35%; on some plots it may decrease to 0%.

The results of the study have shown that dry pine-sedge and pine-moss-lichenous forests occupy the largest areas. In the researched territory plots no. 6, 7, 8 and 12 have been marked (Tab. 2). Therein, the share of mosses is not large

(approximately 3-6%). The following species predominate in the vegetation cover: *Carex stenophylla, Carex praecox, Festuca sulcata, Gypsophilla paniculata, Stipa capillata, Galium boreale, Equisetum sylvaticum, Senecio jacobaea, Spiraea hypericifolia,* etc. Projective cover of lichens may reach up to 45%, mainly represented by *Cladonia* var.

Among mosses the following ground xerophytes take a prevalent position: *Ptychostomum pseudotriquetrum, Ceratodon purpureus, Bryum argenteum, Syntrichia ruralis, Ptychostomum boreale, Polytrichum piliferum* and *Polytrichym juniperinum*. The total number of identified moss species is 12. It makes up 36.4% of all biodiversity of pine forest. These communities are mainly distributed in the north and more rarely – in the north-east of the studied area.

Table 2: Share of mosses in plant communities of fresh moss-lichen-sedgy pine forests

Plot, 20 sq.m.		**Vegetation cover**					
			Higher tracheophytes		**Mosses**		
No	**Coordinates and altitude above sea level**	**Projective cover (%)**	**Species**	**Abundance**	**Moss share (%)**	**Moss species**	**Species activity level**
6	50^0 33’ 13’’N 80^0 56’ 57’’E 325 m	80	*Pinus silvestris var. kulundensis*	Cop.2	6	*Pleurozium Shreberi*	Midactive
			Carex stenophylla	Cop.2		*Polytrichym juniperinum*	Midactive
			Carex praecox	Cop.1		*Ceratodon purpureus*	Less active
			Elytrigia repens	Cop.1		*Ptychostomum pseudotriquetrum*	Midactive
			Festuca sulcata	Sp.		*Syntrichia ruralis*	Midactive
			Silaus besseri	Cop.1		*Ptychostomum boreale*	Less active
			Spirea hypericifolia	Sp.			
			Cladonia var.	Cop.2			
7	50^0 33’ 59’’N 80^0 18’ 50’’E 255 m	75	*Pinus silvestris var. kulundensis*	Cop.2	4	*Polytrichym juniperinum*	Midactive
			Carex stenophylla	Cop.2		*Ceratodon purpureus*	Midactive
			Cladonia var.	Cop.3		*Bryum argenteum*	Midactive
			Spirea hypericifolia	Sp.			
			Gypsophillia paniculata	Sp.			
			Stipa capillata	Sp.			
			Artemisia austrica	Sp.			
8	50^0 25’ 53’’N 80^0 28’ 37’’E 260 m	70	*Pinus silvestris var. kulundensis*	Cop.2	3	*Bryum argenteum*	Midactive
			Carex stenophylla	Cop.2		*Ceratodon purpureus*	Midactive
			Poa angystifolia	Sp.		*Syntrichia ruralis*	Less active
			Artemisia austrica	Cop.1		*Ptychostomum imbricatulum*	Less active
			Festuca sulcata	Cop.1			
			Spirea hypericifolia	Cop.1			
			Pulsatilla multifida	Cop.1			
			Phleum phleoides	Sp.			
			Galatella punctata	Sp.			
			Helichrysum arenarium	Sp.			

12	50^0 25’ 53’’N 80^0 28’ 37’’E 260 m	75	*Pinus silvestris var. kulundensis*	Cop.2	5	*Bryum argenteum*	Midactive
			Carex stenophylla	Cop.2		*Ceratodon purpureus*	Midactive
			Cladonia var.	Cop.3		*Syntrichia ruralis*	Less active
			Festuca sulcata	Sp.		*Ptychostomum imbricatulum*	Less active
			Calamagrostris epigeios	Sp.			
			Potentilla bifurca	Sp.			
			Artemisia scoparia	Cop.1			
			Spirea hypericifolia	Sol.			
Total mean value of cover (%)		75			4,5		

In the burned areas the territory demonstrates a different species composition of the herbal layer, mean value of projective cover, share of mosses and the highest frequency of the following species: *Ptychostomum pseudotriquetrum, Ptychostomum boreale* and *Polytrichym juniperinum.* Tree crown density amounts to 45-50%.

Moss pine forests have the highest rate of species diversity. They are mostly spread to the east and, partly, to the north-east of the city of Semey – plots no. 1, 2, 3, 4, 5 and 13 (Table 3). In this territory, the mean value of projective cover reaches 36%, and mainly consists of mesophytes and hygrophytes species which participate in creation of ground and epiphytic synusiae.

Table 3: Share of mosses in plant communities of moist moss pine forests

Plot, 20 sq.m.		**Vegetation cover**					
No	**Coordinates and altitude above sea level**	**Projective cover (%)**	**Higher tracheophytes**		**Mosses**		
			Species	**Abundance**	**Moss share (%)**	**Moss species**	**Species activity level**
1	50^0 27’ 45’’N 81^0 11’ 24’’E 260 m	90	*Pinus silvestris var. kulundensis*	Cop.2	26,5	*Bryum argenteum*	Less active
			Carex stenophylla	Cop.2		*Ptychostomum pseudotriquetrum*	Highly active
			Cladonia rangiferina и др. лишайники	Sp.		*Pohlia nutans*	Midactive
			Veronica spicata	Sp.		*Helodium blandowii*	Midactive
			Silaus besseri	Sp.		*Brachytheciu m mildeanum*	Active
			Thalictrum minus	Sp.		*Dicranum polysetum*	Midactive
			Populus tremula	Sp.		*Pleurozium Shreberi*	Highly active
			Spirea hypericifolia	Sp.		*Polytrichym juniperinum*	Midactive
			Crataegus sanguinea	Sol.		*Ceratodon purpureus*	Highly active
			Galium boreale	Sp.			
			Senecio jacobaea	Sp.			
			Equisetum sylvaticum	Cop.1			
			Phlomis tuberosa	Sp.			
			Lathyrus	Sol.			

			pratensis				
2	50^0 28’ 21’’N 81^0 13’ 34’’E 263 m	85	*Pinus silvestris var. kulundensis*	Cop.2	18	*Pleurozium Shreberi*	Highly active
			Carex stenophylla	Cop.2		*Ceratodon pupureus*	Less active
			Galium boreale	Sp.		*Polytrichym juniperinum*	Midactive
			Rosa cinnamomea	Sol.		*Dicranum polysetum*	Midactive
			Medicago falcata	Cop.1		*Syntrichia ruralis*	Less active
			Veronica spicata	Cop.1		*Ptychostomum boreale*	Active
			Elytrigia repens	Cop.1		*Ptychostomum pseudotriquetrum*	Highly active
			Equisetum sylvaticum	Cop.1		*Ptychostomum imbricatulum*	Active
			Silaus besseri	Sp.		*Brachytheciu m campestre*	Less active
			Gypsophillia paniculata	Sp.		*Brachytheciu m salebrosum*	Less active
			Populus tremula	Sol.		*Pohlia nutans*	Less active
			Senecio jacobaea	Sol.			
			Dracocephalum nutans	Sp.			
			Vicia tenuifolia	Sol.			
			Cannabis ruderalis	Sp.			
3	50^0 27’ 58’’N 81^0 12’ 25’’E 258 m	95	*Pinus silvestris var. kulundensis*	Cop.2	36	*Pleurozium Shreberi*	Highly active
			Carex stenophylla	Cop.2		*Polytrichym juniperinum*	Midactive
			Equisetum sylvaticum	Sp.		*Dicranum polysetum*	Midactive
			Medicago falcata	Sp.		*Ceratodon purpureus*	Less active
			Spirea hypericifolia	Sol.		*Ptilium crista-castrensis*	Active
			Helichrysum arenarium	Sol.		*Leptobryum pyriforme*	Less active
			Senecio jacobaea	Sol.		*Brachytheciu m mildeanum*	Midactive
			Cannabis ruderalis	Sp.		*Brachytheciu m campestre*	Less active
			Veronica spicata	Cop.1		*Bryum turbinatum*	Less active
			Cynoglossum officinale	Sol.		*Ptychostomum boreale*	Midactive
						Ptychostomum pseudotriquetrum	Active
						Helodium blandowii	Less active
4	50^0 27’ 58’’N 81^0 12’ 25’’E 250 m	90	*Pinus silvestris var. kulundensis*	Cop.2	25	*Pleurozium Shreberi*	Highly active
			Carex stenophylla	Cop.2		*Ptychostomum pseudotriquetrum*	Highly active

			Carex praecox	Cop.1		*Polytrichym juniperinum*	Less active
			Gypsophilla paniculata L.	Sol.		*Dicranum polysetum*	Less active
			Populus tremula	Sp.		*Syntrichia ruralis*	Inactive
			Equisetum sylvaticum	Cop.1		*Pohlia nutans*	Less active
			Helichrysum arenarium	Sp.		*Brachytheciu m mildeanum*	Midactive
			Silaus besseri	Sp.		*Pylaisia polyantha*	Highly active
			Cannabis ruderalis	Sp.		*Sciuro-hypnum populeum*	Midactive
			Dracocephalum nutans	Sp.		*Brachytheciu m campestre*	Less active
						Brachytheciu m salebrosum	Midactive
						Ptilium crista-castrensis	Midactive
5	50^0 27’ 58’’N 81^0 12’ 25’’E 250 m	85	*Pinus silvestris var. kulundensis*	Cop.2	15	*Ceratodon purpureus*	Midactive
			Carex stenophylla	Cop.2		*Ptychostomum imbricatulum*	Less active
			Festuca sulcata	Sp.		*Polytrichym juniperinum*	Midactive
			Thalictrum minus	Cop.1		*Pleurozium Shreberi*	Midactive
			Calamagrostris epigeios	Sol.		*Syntrichia ruralis*	Midactive
			Poa angustifolia	Sp.		*Bryum argenteum*	Inactive
			Pulsatilla multifida	Sp.		*Ptychostomum pseudotriquetr um*	Midactive
			Elytrigia repens	Cop.1			
			Spirea hypericifolia	Sp.			
			Glycyrrhiza glabra	Sp.			
13	50^0 36’ 46’’N 81^0 54’ 01’’E 331 m	82	*Pinus silvestris var. kulundensis*	Cop.2	10	*Polytrichum juniperinum*	Highly active
			Carex stenophylla	Cop.2		*Ptychostomum pseudotriquetr um*	Midactive
			Helichrysum arenarium	Cop.2		*Ceratodon purpureus*	Midactive
			Elytrigia repens	Cop.2		*Brachytheciu m mildeanum*	Highly active
			Equisetum sylvaticum	Cop.1			
			Artemisia austrica	Cop.1			
			Cladonia var.	Cop.1			
Total mean value of cover (%)		88			22		

According to the table 3, the mean value of projective cover amounts to 88%, and moss share makes up 22%. Crown density of trees is 50-60%.

The following species of bryophytes have spread in this territory the most: *Pleurozium Shreberi, Polytrichym juniperinum, Dicranum polysetum, Pohlia nutans, Ptychostomum pseudotriquetrum. Ceratodon purpureus, Bryum argenteum* and *Syntrichia ruralis* are found less frequently than in other dry pine forests. *Ptilium crista-castrensis* grows rarely, but tends to be crowded. This is the only area where *Dicranum flagellare*, the specie that is quite rare for East Kazakhstan, has been discovered.

In total 21 moss species have been discovered in moss pine forests comprising 63.6% of all bryodiversity of the forest.

Based on the acquired data a general calculation table has been developed (Tab. 4).

Table 4: Summary table on key considered parameters

Forest sites	Plot no.	Total value of projective cover (%)	Moss share (%)	Share of higher tracheophytes including base of tree trunks (%)	Tree crown density (%)	Number of moss species
Burned areas	-	60	2-8	52-58	10-15	6
Dry pine forests	9	65	0,5	64,5	40	2
	10	65	0,1	64,9	40	1
		60	0,8	59,2	40	2
	14	65	0	65	40	0
Fresh moss-lichen-sedgy pine forests	6	80	6	74	50	6
	7	75	4	71	45	3
	8	70	3	67	40	4
	12	75	5	70	40	4
Moist moss pine forests	1	90	26,5	63,5	60	9
	2	85	18	67	60	11
	3	95	36	59	55	12
	4	90	25	65	55	12
	5	85	15	70	50	7
	13	82	10	72	50	4

5. DISCUSSION

The results of the study have shown that the species composition and the bryophyte distribution in the territory of Semey ecoregion are considerably influenced by physioclimatic conditions of the environment, suppression degree and phytocenosis that they are native to.

Based on the statistical data analysis (tree crown density, total value of projective cover, share of mosses, activity level of every moss species, species diversity of mosses, species composition of phytocenosis and average annual precipitation) it has been identified that the driest territories of the pine forest are located westward and north-westward, and the territories of average humidity – northward and partly north-eastward. The most humid areas are covered by pine forests on the east and partly on the north-east of the territory.

While moving from the west to the east species diversity of mosses increases from 0-3 to 21, the share of mosses in phytocenosis varies from 0-0.35% to 22-36%.

Regular changes in species diversity and activity of some species become evident in synusiae composition. In the west the driest sites of pine forest demonstrate predominance of *Bryum argenteum* species. *Ceratodon purpureus, Syntrichia ruralis* and *Polytrichum piliferum* are found rarely, while *Polytrichum juniperinum* and *Ptychostomum boreale* species – quite rarely. Eastward *Ptychostomum pseudotriquetrum* specie appears to become part of phytocenosis. In the central part of the forest, primarily in the north, *Bryum argenteum* specie remarkably decreases, while *Ceratodon purpureus, Syntrichia ruralis, Polytrichum piliferum* and *Ptychostomum pseudotriquetrum* species equally predominate. Further to the East *Bryum argenteum* loses its domination and can be found quite rarely. In the north-east *Pleurozium Shreberi* specie suddenly appears more frequently and takes a predominant position. *Polytrichym juniperinum* can be found more often than *Polytrichum piliferum.* In this territory the share of *Pleurozium Shreberi* may reach up to 50% of all moss species. *Dicranum polysetum,* as well as *Pohlia nutans* appears in moss species diversity more frequently.

The Eastern part of the pine forest is distinct for its highest level of species diversity. Compared to the other sites of the forest it is the only area where such species as *Ptilium crista-castrensis* and *Helodium blandowii* can be found.

The statistical analysis of the data presented in table 4 has shown that distribution of bryophytes depends not only on the level of average annual precipitation but on phytocenosis, as well. Thus, it has been identified that the share of bryophytes and their species diversity increase in direct proportion to the thickening of crown density of trees and decrease with the rise of projective cover by high tracheophytes (Fig. 1).

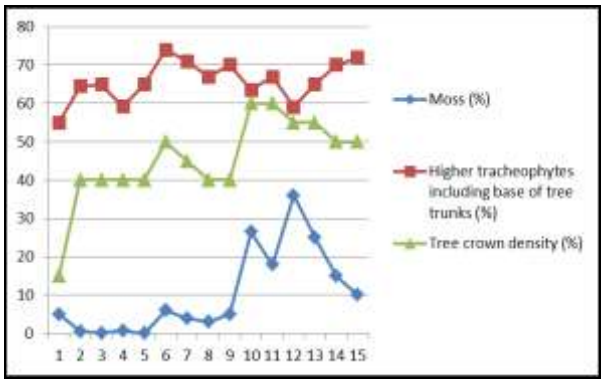

Figure 1: Percentage ratio of moss, higher tracheophytes and tree crown density in plant community on 14 plots and burned areas

6. CONCLUSIONS

Bryophytes are distinguished by their low competitive ability in relation to higher tracheophytes. The following moss species are found to have the highest competitive ability: *Brachythecium mildeanum, Ptychostomum pseudotriquetrum, Bryum argenteum* и *Ceratodon purpureus.*

The results of the comparison of the data obtained from the western and the north-western sites of the pine forest are of particular interest. Moisture conditions are equally low in these territories, but half of the plots are known to have suffered from fires and now they are at the stage of recovering succession; half of them have remained untouched. The plots which remained untouched by fire have shown insignificant moss share (from 0 to 0.8%). The number of registered moss species varies from 0 to 3 (*Bryum argenteum, Ceratodon purpureus*, *Polytrichum piliferum*). While the role of mosses in phytocenosis increases drastically in the burned areas (from 2 to 8%), and the number of species rises to 6, besides the three species mentioned above (*Bryum argenteum, Ceratodon purpureus*, *Polytrichum piliferum*) the following ones appear: *Syntrichia ruralis, Ptychostomum pseudotriquetrum, Ptychostomum boreale.* This fact can be explained by a low level of competition with high tracheophytes, microclimatic environmental conditions, and a low suppression degree.

7. ACKNOWLEDGEMENT

This study was partly implemented in the framework of “Forest conservation and increase of forest area on the territory of the Republic of Kazakhstan” Project. Forest monitoring and analysis of environmental modification on project’s territory of pine forests of the Irtysh river region in 2011-2013 was carried out by “Terra” Centre of remote sensing and GIS technologies. The authors also express deep gratitude to the staff of “Terra” Centre of remote sensing and GIS technologies.

8. REFERENCES

[1] Alehin V.V. Methods of field study of vegetation and flora. – Moscow, 1938. – 190 p.
[2] Barthelemy Hélène, Dorrepaal Ellen & Olofsson Johan. Defoliation, soil grazing legacy, dung and moss cover influence growth and nutrient uptake of the common grass species, Festuca ovina// Ecology and Environemntal Sciences, Umeå 2016. P:1-36.
[3] Catherine M. Dieleman, Brian A. Branfireun, James W. McLaughlin, Zoë Lindo. Climate change drives a shift in peatland ecosystem plant community: Implications for ecosystem function and stability// Global Change Biology. V.21, Issue 1, January 2015. P: 388–395.
[4] Cherepanov S.K. Vascular plants of the USSR. - L.: Nauka, 1981. - 510p.
[5] Daniel Udd, Kalle Mälson, Sebastian Sundberg, Håkan Rydin. Explaining species distributions by traits of bryophytes and vascular plants in a patchy landscape// Folia Geobotanica, 2015. Vol. 50, Issue 2. P: 161-174.
[6] Egorina A.V., Zinchenko Ju.K., Zinchenko Ju.S. Physical geography of East Kazakhstan. - Ust-Kamenogorsk, 2002. -182p.

[7] Garibova L.V, Dundin B.K., Koptjaeva T.F. & Filin V.R. Algae, lichens and bryophytes of the USSR. Moscow «Mysl'», 1978 - 368p.
[8] Granath G, Strengbom J, Rydin H Rapid ecosystem shifts in peatlands: linking plant physiology and succession// Ecology, 2010, Vol.91. P: 3047-3056.
[9] Gubanov I. A., Kiseleva K. V., Novikov V. S., Tihomirov V. N. The illustrated keys to plants of plants of Kazakhstan. – Alma-Ata: Science, 1969-1972. - Volumes 1-2.
[10] Ignatov M.S., Afonina O.M. & Ignatova E.A. 2006. Checklist of mosses of East Europe and North Asia. – Arctoa 15: 1-130.
[11] Ignatov M.S., E.A. Ignatova. Flora of mosses Central part of European Russia. Vol.1. Moscow. 2003. - pp: 1-608.
[12] Ignatov M.S. & Ignatova E.A. Flora of mosses Central part of European Russia. Vol.2. Moscow, 2004. - pp: 609-944.
[13] IPCC. 2013. Climate change 2013: the physical science basis. Cambridge: Cambridge University Press.
[14] Juha M. Alatalo, Annika K. Jägerbrand, Ulf Molau. Seven years of experimental warming and nutrient addition causes decline of bryophytes and lichens in alpine meadow and heath communities//Digitala Vetenskapliga Arkivet,14 Dec. 2014. PeerJ PrePrints 2:e672v2https://doi.org/10.7287/peerj.preprints.672v2
[15] Kirsten K. Deane-Coe, Marguerite Mauritz, Gerardo Celis, Verity Salmon, Kathryn G. Grummer, Susan M. Natali & Edward A. G. Schuur. Experimental warming alters productivity and isotopic signatures of tundra mosses. Ecosystems, 2015, Vol. 18, Issue 6. P: 1070-1082.
[16] Korchagin A.A. Intraspecific (population-based) composition of plant communities and methods of its study // Field geobotany. - M.-L.: Nauka, 1964. - V.3. - P.63-131.
[17] Kuhry P, Nicholson B.J., Gignac L.D., Vitt D.H., Bayley S.E. Development of Sphagnum-dominated peatlands in boreal continental Canada// Canadian Journal of Botany, 1993, Vol.71. P: 10-22.
[18] Lenka Kuglerová, Mats Dynesius, Hjalmar Laudon, Roland Jansson. Relationships Between Plant Assemblages and Water Flow Across a Boreal Forest Landscape: A Comparison of Liverworts, Mosses, and Vascular Plants// Ecosystems, 2016. V.19, Issue 1. P: 170-184.
[19] Lindo Z, Nilsson M-C, Gundale MJ. 2013. Bryophyte–cyanobacteria associations as regulators of the northern latitude carbon balance in response to global change. Glob Change Biol, 2013 Mar 25, V.19. P:2022-2035.
[20] Lynette R. Potvin, Evan S. Kane, Rodney A. Chimner, Randall K. Kolka, Erik a. Lilleskov. Effects of water table position and plant functional group on plant community, aboveground production, and peat properties in a peatland mesocosm experiment (PEATcosm)// Plant Soil, 2015. V. 387. P:277-294.
[21] Martin A. Stapanian, William Schumacher, Brian Gara & Nick Viau. Mosses in Ohio wetlands respond to indices of disturbance and vascular plant integrity// Ecological Indicators, Vol, 63, April 2016. P: 110-120.
[22] Micael Jonsson, Paul Kardol, Michael J. Gundale, Sheel Bansal, Marie-Charlotte Nilsson, Daniel B. Metcalfe & David A. Wardle. Direct and indirect drivers of moss community structure, function, and associated microfauna across a successional gradient// Ecosystems, 2015, Vol. 18. P: 154-169.
[23] Munir T.M., Xu B., Perkins M., Strack M. Responses of carbon dioxide flux and plant biomass to water table drawdown in a treed peatland in northern Alberta: a climate change perspective. Biogeosciences, 2014. V.1. P1:807-820.
[24] Pavlov N.V. Flora of Kazakhstan I-IX of that. Science. Alma-Ata. –1965.
[25] Savicz-Lyubitskaya, L.I. & Smirnova Z.N. Handbook of mosses of the USSR. The acrocarpous mosses. Leningrad, Nauka, 1970. – 822p.
[26] Shestakova A.A. The dissertation on competition of a scientific degree of candidate of biological Sciences on the theme "Ecological-coenotic and floristic features of the organization of priority on the territory of Nizhny Novgorod region». - Nizhny Novgorod, 2005. – 23p.
[27] Skvorcov A.K. Herbarium. - M.: Nauka, 1968. – 263 p.
[28] Skvorcov A.K. Herbarium (manual on methods and techniques of collecting herbarium. - M.: Nauka, 1977. – 121 p.
[29] Soudzilovskaia N.A., Bodegom P.M., Cornelissen J.H. Dominant bryophyte control over high-latitude soil temperature fluctuations predicted by heat transfer traits, field moisture regime and laws of thermal insulation// Functional Ecology 2013. Vol. 27, Issue 6. P:1442–1454.
[30] Street LE, Subke J-A, Sommerkorn M, Sloan V, Ducrotoy H, Phoenix GK, Williams M. 2013. The role of mosses in carbon uptake and partitioning in arctic vegetation. New Phytologist, V.199, Issue 1, 24 APR 2013. P:163–175.
[31] Sundberg S. Åtgärdsprogram för bevarande av rikkärr [Action plan for Swedish rich fens]// Naturvårdsverket, 2006, Rapport 5601, Stockholm. 80pp.