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SPATIAL AND TEMPORAL VARIABILITY OF DRY STEPPES OF EASTERN MONGOLIA

ABSTRACT

Spatial-temporal structure and coenotic diversity of dry steppes of Eastern Mongolia was identified by analyzing characteristics of naturally occurring vegetation connection to the regional landscape structure. Different types of combinations of plant communities (phytocoenochores) were determined in the vegetation structure of the Eastern Steppe Station Tumén-Tsogt (in Sukhebator district). Temporal dynamics of steppe ecosystems was defined from the studies of steppe cover fluctuations in 2008. The coenotic role of eight annual plant species that form synusiae in the steppe communities was shown through analysis of species constancy, projective cover, and activity. Knowledge about the trend of successions and the manifestation of fluctuations in vegetation cover is necessary for the development of science-based system of management options to maintain the number and abundance of different plant groups in plant communities. Monitoring the state of natural ecosystems has a major scientific and practical importance, since steppe ecosystems are the basic component of the pasture's resources of the country.

KEY WORDS: steppe ecosystem, vegetation structure, biodiversity, annual species, fluctuations, dynamics of communities, monitoring

INTRODUCTION

Studying the fundamental properties of vegetation and, above all, its spatial-temporal structure has always been in the spotlight and one of the urgent tasks of biogeography. A variety of natural plant complexes, their distribution patterns (spatial differentiation of steppe communities in relation to the gradients of environmental factors), and temporal dynamics of communities caused by various environmental changes represent a present-day ecological potential of the territory. Steppe ecosystems exist in constant dynamics related to changes of environmental parameters caused by natural and anthropogenic impact. Fluctuations and successional changes are regarded as certain stages of steppe communities in a series of dynamic manifestations. However, the natural invariants of steppe ecosystems have certain average characteristics that determine their primary structure and relative stability to the impact factors. Indigenous communities and their varying components represent a single dynamic system.

Sustainable development of steppe ecosystems is associated with preservation or restoring their natural structure. Vegetation cover is one of the most important indicators of ecological condition of the whole region and serves as an explicit measure of its well-being or as an indicator of existing environmental problems. To solve the pressing problems of balanced (sustainable) development of steppe regions, a reliable information on the current state of natural ecosystems and their base constituent, i.e., biodiversity, is necessary.

In 2008, in practically all communities of the dry-steppe of the Eastern Mongolian steppe biome, significant changes in their organization have been studied. These changes were manifested by strong development of synusiae of annual species and changes in the composition of dominants, structure, products, and physiognomy of the steppe communities. Such stages of steppe ecosystem development represent cyclical changes and relate to the fluctuations caused by changes in climatic parameters (volume and regime of rainfall) in the current and previous years.

A comparative analysis of changes occurring in steppe ecosystem and the modern trends of their further development are of interest to the general scientific studies of steppes and are necessary for developing practical recommendations for their use and conservation.

OBJECTS OF STUDY AND METHODS

The Eastern Steppe Station Tumén-Tsogt (in Sukhebator district) is located in the Herlen River basin and practically coincides with the area of a similarly named Soum of Sukhebator district. The steppes of this territory pertain to the Eastern Mongolian sub-province of the Eurasian steppes according to botanic-geographic demarcation [Lavrenko, 1970]. Studies of the arid steppes of the Eastern Mongolian biome at the Tumén-Tsogt Station have a long history [Volkova, 1988; Khramtsov, Dmitriev, 1995].

The specific feature of the Eastern Mongolian steppes is that they combine features of mountain and plain steppes characteristic of the landscape structure of the territory. The vegetation consists of herb–bunchgrass and dry bunchgrass steppes on chestnut soils whose distribution corresponds well to the geomorphologic structure and the soil cover of the territory. The Station area is about 2000 km^2.

The relief at the territory consists of a hummock denudation plain with a system of uneven-aged hills and of intermontane depressions between the hills. Apical surfaces of the hills vary in morphology depending on lithology of the composing rocks. In the areas with the dominance of weak sandstones, shale, and effusive rocks, there are smooth dome-shaped or flattened tops. Rocky peaks and ridges are formed by outcroppings of granite, quartzite, jasper and limestone (Fig. 1).

The climate of this part of Eastern Mongolia is continental: summers are short (the average July temperature is +20°C), winters are long and almost snow-free (the average January temperature is –20°C). The average annual rainfall is 200-240 mm, reaching 360-460 mm in some years. According to the Underhan

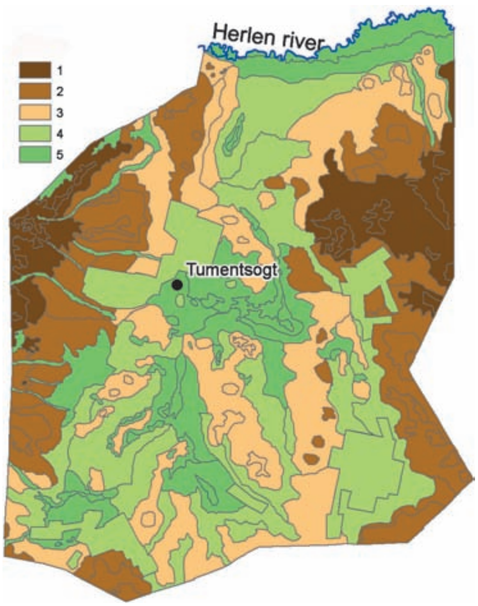

Fig. 1. The types of terrain at the Tumén-Tsogt Station.

1 – high hummocks (1100–1350 m asl), 2 – medium-sized hummocks (1000–1200 m), 3 – low hummocks (950–1000 m), 4 – plains (800–950 m), 5 – depressions (750–800 m) meteorological station, the nearest to the Tumén-Tsogt (47° 19′ N, 110° 38′ E; altitude –1,035 m), the maximum precipitation, as a rule, falls in the second half of July and August; two or three out of each five years are drought (Fig. 2). On average, 160–170 mm falls during the growing season. The survey year (2008) was a wet year in the multiannual cycle; 316.8 mm fell during the growing season (May-August) with most precipitation (208.5 mm) in the early summer (May-June).

There were significant fluctuations of precipitations in the previous years also. Thus, in 2002, 399 mm fell during the growing season, including 245.4 mm in May-June. However, extremely wet years may be preceded by extremely dry. In 2006, only 115 mm fell during the growing season, including 44.6 mm in May-June; in 2007, 41.9 mm fell during the season and 16.0 mm in May-June. These fluctuations of precipitations were the cause of the summer droughts in these years (Fig. 2).

Climatic conditions of 2008 established as a result of this precipitation promoted the development of annual species that prevailed in herb cover in many types of steppes at the Station.

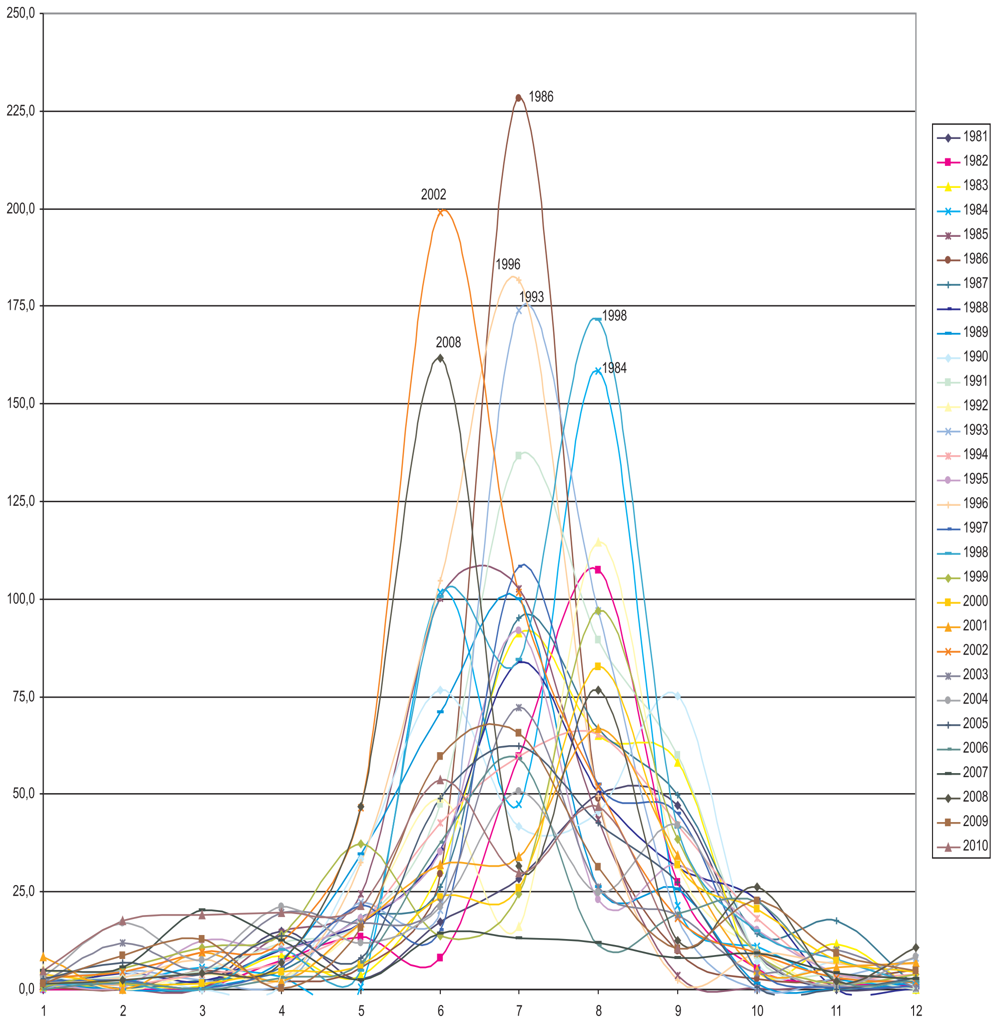

Fig. 2. Precipitation at the Tumén-Tsogt Station in 1981 to 2010 (from the data of the Underhan meteorological station). The horizontal axis: months from January to December; the vertical axis: precipitation (mm)

DISCUSSION OF THE RESULTS

Spatial organization and coenotic diversity of the Eastern Mongolian steppes

Vegetation structure that evolves in the process of its development determines stability and spatial distribution of communities according to natural conditions and geomorphological composition of the territory [Sochava, 1978]. In phytocoenology, there is a notion of the types of territorial units as regular combinations of communities of a certain hierarchical level that compose the optimum spatial vegetation system contributing to its highest stability. Among different elementary chorological units (i.e., phytocoenochores or combinations) of the Eastern Mongolian steppes, several typical structures have been identified. Micro-combinations have a relatively large spatial extent and represent, as a rule, sequential stages of the same ecological range or of the same successional process. These stages may include complexes, ecological ranges or series, and micro-zonal ecological ranges. In meso-combinations, plant components are primarily influenced by orography and they are of a relatively greater spatial extent. Each plant component of meso-combinations may have its own way of development. Meso-combinations include: meso-complexes, phyto-catenae, and expositional combinations of phyto-catenae. Macro-combinations are formed on the hill slopes following a pattern of high level of ecotopic differentiation. The elements of macro- combinations represent a single and complete ecological range, from watershed surfaces to river valleys, that are integrated an phyto-catenae and a composite part of an elementary basin. A macro-geochore may be represented by a geomorphologic or a hummock complex of the steppes. This complex includes serial communities of hill topes, expositional combinations of phyto-catenae of transitional parts of slopes, and homogeneous communities of slope aprons and their accumulation parts.

Phyto-catenae are the main structures of the mountain vegetation. Their definition is based on the concept of runoff-geochemical evolution of landscapes [Glazovskaya, 1988] and slope development [Voskresenskyi, 1971; Ogureeva, 1994]. Within phyto-catanae, the integration of elementary ecosystems of the eluvium, trans-eluvium (transit), and accumulative positions into linked series takes place, defining spatial differentiation of vegetation on the slopes. Functioning together, they are the product of the close interaction between all the components and with the environment. All communities of phyto-catenae are dynamic and, with time, undergo modification of structural and floristic parameters as a result of slope ecotope transformations. Thus, communities of mountain slope represent an integrated, spatially-dynamic system that characterizes an elementary basin. Phyto-catenae on slopes of different exposures form expositional combination of phyto-catenae that are located within altitudinal belt of the vegetation cover. On the Station's territory, the expositional combinations of the steppe phyto-catanae have been isolated for all types of hummocks [Ogureeva and al., 2011].

The steppe complex of the high hummocks. High denudational hummocks and low-mountain massifs with steep erosion-dissected slopes and intermountain valleys are composed of granitoids. They occupy 240.4 km^2 (11.2% of the total Station's area). The maximum absolute elevations reach 1100-1350 m; relative – 200-250 m. Shrub communities consisting of *Betula fusca* are confined to the upper elevations, while *Armeniaca sibirica-Amygdalus pedunculata* communities occupy near-apical sites on the slopes of the high and intermediate hummocks. Petrophytic steppe variants (serial vegetation) occupies rank and rocky surfaces of the apical parts of the hills. *Stipa baicalensis* and *Carex pediformis* dominate in the vegetation cover of the complex. Herb-stipa and herb-sedge steppes represent the most mesophilic types of the Eastern Mongolian steppes with participation of species of forest-steppe herb communities (*Clematis hexapetala*, *Hemerocalis minor*, *Rhaponticum uniflorum*. *Schizonepeta multifida*, and *Stellera chamaejasme*). They occupy the transit parts of the slopes of different exposures forming expositional combination at different altitudinal levels. Meadows are located in the erosion valleys.

The steppe complex of the intermediate hummocks. The hummocks of intermediate height (1000-1200 m) have gentle slopes and dome-shaped tops. They are predominantly composed of Permian effusions, Jurassic tuffaceous sandstones, andesite, and, more rarely, of basalt and granite, and occupy 424.2 km^2 (22.6%).

Bunchgrass steppes dominate the vegetation of the low and intermediate hummocks. On the near-apical parts of the slopes, there are diverse petrophytic series of stipa (*Stipa grandis*, *S. krylovii*, *S. sibirica*). The shrub *Ulmus pumila* formations are characteristic of the rocky stony and rank habitats of the intermediate and low hummocks. The formations of three-stipa steppes (*Stipa grandis*, *S. krylovii*, *S. sibirica*) are the most diverse in their communities' floristic composition. They are typical for the transitional parts of the southern slopes of the intermediate hummocks, forming expositional combinations with the herb-stipa steppe formations of *Stipa grandis* and *S. krylovii* on the slopes of the northern exposure. The herb-grass-stipa (*Festuca lenensis, Stipa krylovii*, *Stipa sibirica*) steppes often contains *Lespedeza dahurica* and *Ephedra sinica*. The herb-three stipa- steppes with *Caragana microphylla*, and *C. stenophylla* form the basis of vegetation cover in the accumulative parts of the slopes of the intermediate and low hummocks.

The steppe complex of the low hummocks. The low hummocks predominate in the area occupying 488.6 km^2 (25.8%). They mainly consist of granites and syenites. Their elevations are 950-1000 m with the highest peaks reaching 1150 m. Relative elevations are 100-150 m. The tops of the hills are occupied by serial steppe vegetation (*Festuca lenensis*, *Koeleria cristata*, *Agropyron cristatum*) and shrubs (*Dasiphora fruticosa*, *Caragana microphylla*, *C. stenophylla*, *Spiraea aquilegifolia*). The slopes of the low hummocks are often covered with xerophytic formations *Stipa krylovii* with: *Leymus chinensis*, *Cleistogenes squarrosa*, *Carex korshinskyi*, *C. duriuscula*, and *Kochia prostrata*. Combinations of arid stipa steppes (*Stipa krylovii* with *Cleistogenes squarrosa*, *Leymus chinensis*) with wormwood (*Artemisia frigida*)–stipa and sedge (Carex duriuscula)–stipa steppes occupy different expositional locations. In the lower parts of the hills near saline depressions, stipa steppes (*Stipa krylovii)* grow together with onion genus (*Allium odorum*, *A. tenuissimum*, *A. bidentatum*)–sedge steppes.

Vegetation of the plains. Gently rugged plains with slight slopes and delluvial aprons (800–950 m) with shallow saline depressions in the axial parts, occupy close to 410.4 km^2 (21.2%) of the somon area. Stipa formation (*Stipa krylovii)* and communities of rhizomous sedges and grasses are characteristic of the plains. Communities of formation *Leymus chinensis* with *Carex duriuscula*, *Artemisia frigida*, and *Kochia prostrata* are spread along the margins of the saline depressions. Communities of sedge formation (*Carex duriuscula*, *C. korshinskyi*) are typical of the aprons and the intermountain plains. There are variants of mesophitic onion–sedge steppes (*A. odorum*, *A. tenuissimum*, *A. bidentatum*) on the plains adjacent to the Herlen River valley.

Vegetation of the depressions. The bottoms of the depressions with adjacent gently sloping alluvial aprons of waterways occupy 376.4 km^2 (19.2%). The depressions have saline complexes of halophytic herbs (*Saussurea salicifolia*, *S. amara*, *Suaeda prostrata*) and communities of grass (*Puccinellla tenuiflora*, *Hordeum brevisabulatum Achnatherum splendens*).

The coenotic diversity of the Steppe Station Tumén-Tsogt has been presented on a large-scale map (1:200 000) of the actual vegetation cover [Ogureeva et al, 2011]. The legend of this map is based on the eco-geographical approach and reflects the connection of the steppes with landscape features of the territory. All typological units of vegetation are grouped according to their spatial location within the terrain.

The map shows the distribution of vegetation as a homogeneous community and as various types of structural units of vegetation at the levels of micro-, meso-, and macro-phytocoenochores (combinations) [Ogureeva et al 2011]. In the vegetation structure of the hummocks, phyto-catenae associated into expositional combinations and petrophytic series of communities are most spread. Serial vegetation covers 66.4 km^2 (3.3% of the Station's area); expositional combinations of phyto-catenae – 1361.5 km^2 (65.2%); bush thickets – 8.1 km^2 (0.4%). On the plains, steppe communities occupy 414.3 km^2 (21.3%), communities of saline habitats – 191.1 km^2 (9.5%), and floodplain series – 12.0 km^2 (0.6%).

The temporal structure of the Eastern Mongolian steppe biome

The 2008 survey of the Eastern Mongolian steppes was a part of the monitoring of the current ecosystem status. This was an important component of the effort to re-map vegetation, which made it possible to identify qualitative and quantitative changes in the vegetation component of the ecosystems, and also to identify the distribution and direction of the main natural and anthropogenic processes. All steppe areas, except for the protected territory of the Khar Yamaat Nature Reserve in the high hummocks west of the Station, were subject to a long-term year-round grazing. Therefore, background anthropogenic pressure throughout the Station is relatively even. The current state of the steppe ecosystems at the Station is assessed as satisfactory on a 5-point scale designed to evaluate ecosystem state [Ecosystems.., 1995].

The role of annual species in the steppe ecosystems.

Traditionally, analysis of the composition of steppe phytocenoses and their classification is based on the characteristics of perennial species substantially resistant to multi-temporal changes under the natural conditions. These species are constantly present in the communities reflecting the specificity of the natural habitat and floristic composition of the primary communities of steppes. The composition of the main components of the steppe communities (bunchgrass and rhizomatous grass) remains practically unchanged; however, from year to year, these species may experience alterations of their life-forms and may play different roles in the community.

The alternation between wet and dry years in the multiyear development of the steppes has led to the fluctuations in the grass cover. Climatic conditions in recent years (drought of 2006–2007; rainfall in the early summer of 2008) contributed to the massive development of annual plant species in all types of these steppes. They provided for a temporary increase in the species richness, projective cover, productivity, and other indicators of the structure and composition of the steppe communities. Annual plants can represent competitors to perennial species for moisture and mineral elements in steppe communities. At the same time, they form the upper phytocoenotic horizon up to 60 cm in height overshading perennial species and favoring their development. Annual species increase the mass of litter and improve the conditions of over-wintering perennials. Mineralization of litter promotes deposition of substances into the nutrient cycling and improves soil conditions of habitats. Simultaneous development of annual species in different types of steppes in extreme years, though smoothes coenotic diversity, does not destroy the natural specificity of steppe communities, whose invariants are preserved.

During the survey of the steppes at the Station in 1994, the average year in terms of moisture indicators (see Fig. 2), it was noted that in the steppes, annual species (*Chenopodium viride*, *C. acuminatum*, *C. aristatum*, *Salsola monophera*, *S. collina,* and *Artemisia palustris*) were present infrequently and in small numbers. However, their role increased locally with the impact of grazing, rodents, and on the fallow lands (Miklyaeva and Lysak, 1996). The 2010 summer sampling survey (also the average year in terms of precipitation during the growing season) of the steppe communities showed that coenotic diversity of the steppes remained the same as in 2008, however the fluctuations of species composition in the form of synusiae of annual species were not manifested. Some of the annual species were present in the communities, but did not play any meaningful coenotic role. Comparison of these materials suggests that temporal conditions (fluctuations) of the steppes occupy a certain place in the multiyear natural dynamics of steppe ecosystems. The fluctuations as cyclic changes in ecosystems represent an integral part of their natural dynamics. Self-regulation of steppe ecosystems restores the original structure of the communities. In the multiyear development cycle of the steppes, their composition is marked with changes at the population level of species-dominants and species-determinants that remain in the communities at all variations of the hydrothermal regime.

Floristic richness of the steppe communities was markedly reduced: in the dry years, from 40-45 species/100m^2 to 12-15 and, rarely, to 7-8 species. As a result of mass development of annual plants, the total projective cover of grass steppes rose to 50-80%, but the true coverage (swarding) was low, not greater than 10-20%. This is typical for the well-defined stages in a series of fluctuating alternations; annual species are the fluctuation dominants in the steppe communities [Rabotnov, 1978] and define their appearance.

In the steppes of the Station in late July – early August of 2008, eight annual species of plants were found. *Chenopodium viride* can develop in the broadest range of conditions. This specie has a wide range from Karelia to the Far East, where it grows in forests and is common in all forest-steppe and steppe regions. Three species are typical to forest-steppe and steppes. *Salsola collina* grows in the areas from the Volg a region and Western Siberia to Altai and Dauria, the Ussuri river valley, and, further, to Mongolia, China, and Tibet. *Axyris amarantoides* grows from Western Siberia and Altai to Dauria and can be found in China, Tibet, and the steppes of Mongolia. The Daur-Mongol species of *Artemisia palustris* grows from Altai to Dauria and Northern China. Two species are typical of steppes. *Chenopodium aristatum* has a wide range and grows from the Middle Dnieper and the Caucasus to Mongolia, China, and Tibet. *Chenopodium acuminatum* occurs from Western Siberia and Trans-Balkhash to Mongolia and China. Two species are found in the steppes and deserts. *Artemisia scoparia* has a wide Eurasian range. Central Asian specie *Salsola monopthera* has a narrower area and occurs in arid and desertified steppes of Mongolia.

These annual species are well adapted to the natural conditions of the steppes of Eastern Mongolia. Their participation in the communities and distribution are determined by specific features of their biology and ecological plasticity. Environmental conditions of plant habitats vary considerably in hypsometric profile influencing the coenotic role of annual species in the communities (Table 1). The coenotic role was assessed based on the constancy and abundance of the species in the communities. Constancy of species is the number of each specie found, expressed as a percentage, in the geo-botanical descriptions at different altitudinal levels of the territory (0–20% – class I of constancy, 21–40% – II, 41–60% – III, 61–80% – IV, and 81-100%-V). Six annual species were recorded in the steppe communities at all elevations. *Chenopodium viride, C. aristatum* and *Salsola collina* had high classes of constancy (IV–V classes) in

Table 1. Constancy and projective cover of the annual plants in the communities at different elevations of the relief

Types of terrain	Hummocks						Plains		Depressions	
	High		Intermediate		Low					
Projective cover (F) Constancy classes (D)	F	D	F	D	F	D	F	D	F	D
Chenopodium viride	1	IV	4	V	4	V	4	V	4	V
Salsola collina	1	I	5	IV	4	V	3	III	3	V
Chenopodium aristatum	2	IV	3	IV	3	V	4	III	3	IV
Salsola monopthera	1	I	1	I	1	I	4	III	3	I
Axiris amaranthoides	3	I	2	II	2	III	2	III	2	II
Chenopodium acuminatum	1	III	1	II	1	II	1	I	1	I
Artemisia palustris	–	–	1	I	3	II	1	II	4	II
Artemisia scoparia	–	–	1	I	2	I	1	I	2	II

Classes of constancy (D): I – 0–20%, II – 21–40%, III – 41–60%, IV – 61–80%, V – 81–100% (number of recordings in the geo-botanical descriptions, in %).
Projective cover of species (F): 1 – very low (less than 1–5%), 2 – low (6–10%), 3 – intermediate (11–20%), 4 – high (21–40%), and 5 – very high (41–70%).

most communities. Constancy of *Salsola monophera*, *Chenopodium acuminatum,* and *Axyris amaranthoides* did not exceed the average values (III). Wormwoods (*Artemisia palustris* and *A. scoparia*) were not found in the communities of the high hummocks; their permanence in the communities of other altitudinal levels were low and did not exceed the values for class II.

The abundance of plant species was assessed according to their projective cover as a measure of their coenotic role in the structure of the steppe communities at the Station (see Table 1). Two species, i.e., *Salsola collina* and *Chenopodium viride,* contributed the most to the projective cover (21–40%) of the communities of different altitudinal levels. The highest abundance indices were characteristic of Salsola *collina*; its projective cover in shrub steppes (*Caragana microphylla, C. stenophylla*) and three-stipa (*Stipa grandis, S. krylovii, S. sibirica*) steppes on the slopes of the intermediate hummocks reached 60–70% (Fig. 3). The projective cover

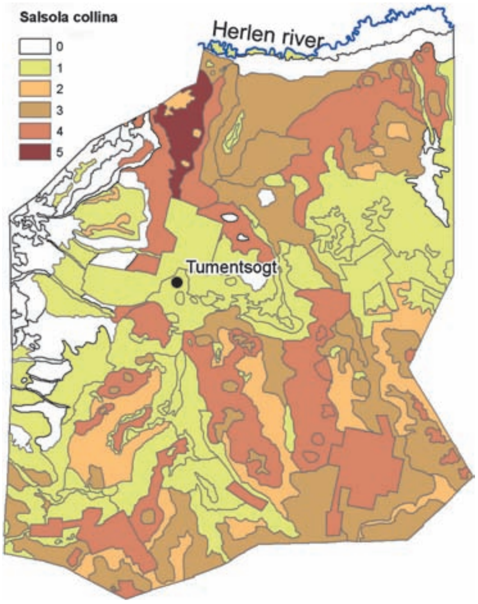

Fig. 3. Coenotic role of *Salsola collina* **(the abundance of species based on the projective cover in %):**

0 – the specie is absent, 1 – up to 5%, 2 – low (6–10%), 3 – intermediate (11–20%), 4 – high (21–40%), and 5 – very high (41–70%)

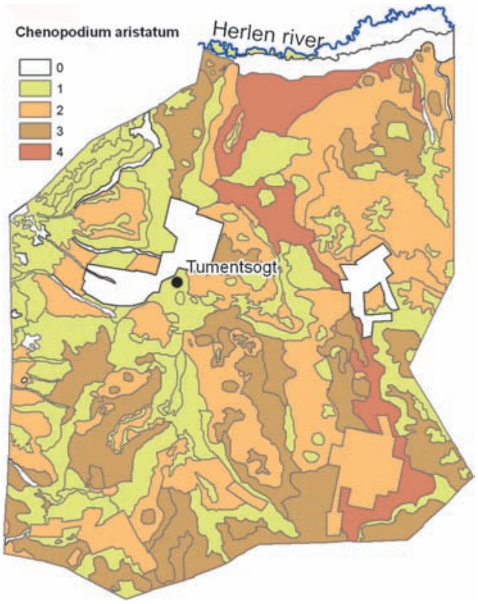

Fig. 4. The coenotic role of *Chenopodium aristatum***:**

0 – the specie is absent, 1 – up to 5%, 2 – low (6–10%), 3 – intermediate (11–20%), and 4 – high (21–40%)

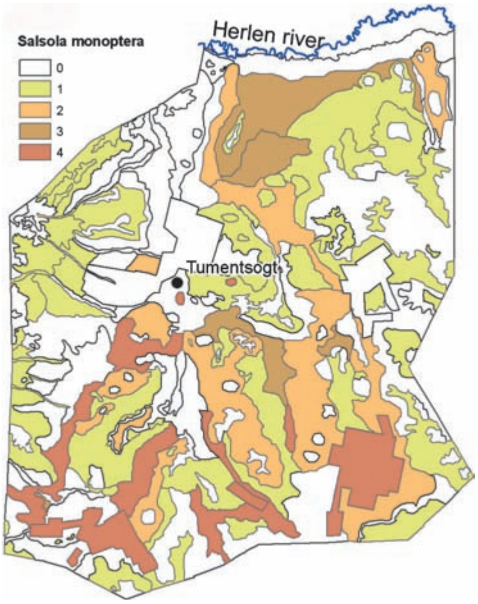

Fig. 5. The coenotic role of *Salsola monophera***:**

0 – the specie is absent, 1 – up to 5%, 2 – low (6-10%), 3 – intermediate (11–20%), and 4 – high (21–40%)

of these species decreased to 11–20% in the communities of the plains and depressions. *Salsola collina* rarely grows in the high hummocks. The ability of *Salsola collina*, along with other annuals, to form the appearance of the steppes of Mongolia in wet years has been previously noted by A.A. Junatov [1954].

The coenotic role of the annual species in communities of the same high-altitudinal level varied considerably (see Table 1). *Chenopodium aristatum* had the greatest coenotic role (projective cover 21–40%) in the communities of the plains in (Fig. 4), while *Salsola monopthera* and *Artemisia palustris* – in the depressions. *Salsola monopthera* had its maximum projective cover (40%) in the stipa (*Stipa krylovii*) steppes on the plains adjacent to the saline depressions (Fig. 5). The high projective cover (40%) was also observed for *Salsola monopthera* in the communities of the fallow land. The coenotic role of other annual species was negligible. Low and very low coenotic importance was found for the species whose projective cover never exceeds 10% – *Axyris amarantoides*, *Chenopodium acuminatum, and Artemisia scoparia* (see Table 1).

Annual plants' activity represents an integral indicator of their role in the steppe communities (Yurtsev, 1968). Activity is calculated as follows:

$$A = \sqrt{FD},$$

where *A* – activity of a specie, *F* – average projective cover (%), *D* – constancy (%).

Classes of activity: I – very active (31–42%), II – high-level (21–30%), III – intermediate (13–20%), IV – low-activity (7–12%), and V – inactive (1 – 6%).

Activity of annual and biennial species varied in different types of steppe mountain complexes (Fig. 6). In the high hummocks, all annual species were inactive; two species – *Artemisia scoparia* and *A. palustris* do not even occur in the steppes at this level. In the intermediate hummocks, there were two species (*Chenopodium viride, C. aristatum*) that

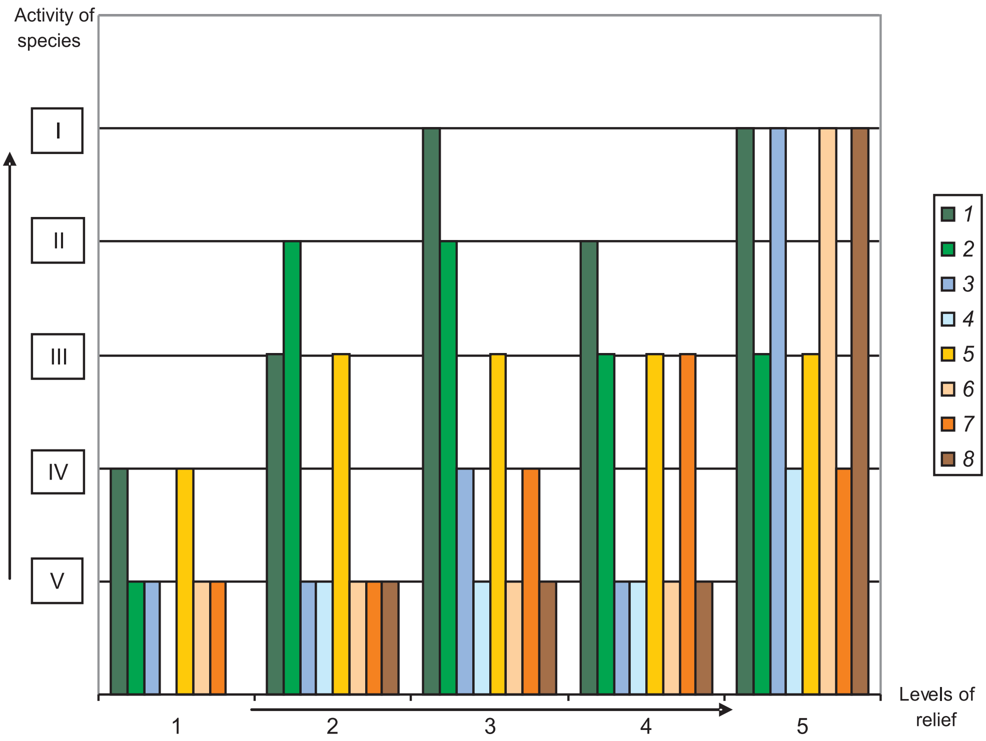

Fig. 6. Activity of annual species in the communities of different types of hummocks.

Types of hummocks: 1 – high, 2 – intermediate, 3 – low, 4 – plains, 5 – depressions.

Activity of species: I – very active, II – highly active, III – intermediate, IV – low active, V – inactive.

Species of annual plants: 1 – Chenopodium viride, 2 – Salsola collina, 3 – Axyris amaranthoides, 4 – Artemisia palustris, 5 – Chenopodium aristatum, 6 – Chenopodium acuminatum, 7 – Artemisia scoparia, and 8 – Salsola monophera

were moderately active (III), and five species that were inactive (V). Activity of *Salsola collina* was mostly high (II) in the steppes of the intermediate and low hummocks. Activity of *Chenopodium viride* had its maximal values (I) in the steppes of the low hummocks. Intermediate activity (III) was observed for *Chenopodium aristatum* in the communities of all elevation levels – from the intermediate hummocks to the depressions. In the steppe communities of plains, high activity (II) was characteristic of *Chenopodium viride,* and intermediate – of *Salsola collina* and *S. monopthera*. High activity in the communities of the depressions was common to all annual species and was maximal in four species.

The steppe communities have been recovering on the abandoned fallow land which occupies 15% of the Station area. The fallow lands are at different stages of the secondary successions. The average age of the fallow land is 15-20 years. The total projective cover of grass is high (50%), while swarding does not exceed 10%. At the initial stages of the secondary successions, indicator species of the former tillage (*Lappula intermedia*, *Setaria viridis*, *Convolvulus arvensis*, *Fallopia convolvulus*, etc.) were present. Most of the grasses were annual species: *Chenopodium viride*, *Salsola collina*, and *Salsola monopthera*. They were constantly present in the grass cover and often form a high-projective cover (21-40%). The fallow lands were characterized by increasing activity of the annual species with *Chenopodium viride*, *C. aristatum*, and *Axyris amarantoides* mostly active, while *Artemisia scoparia*, *A. palustris*, and *Salsola collina* had intermediate (III) activity.

CONCLUSION

The research on spatial-temporal structure of steppes is of special scientific and practical importance and is the basis for studying ecosystems at the current level of their protection and restoration. In extreme years, temporary synusiae appear as a result of varying volume and regime of precipitation. Annual species become fluctuating dominants during this period. [Rabotnov, 1978].

Analysis of the 2008 studies of the current state of the steppe ecosystems showed fluctuations in the sequence of their temporary states with clearly expressed annual species synusiae. Each annual species in a synusia is characterized by a specific ecological range and the coenotic optimum. These species had different ecological amplitude and played different coenotic role in the steppe communities. The species with broader ecological amplitude (*Chenopodium viride, Salsola collina*) in the steppes of Eastern Mongolia played a more significant role in the steppe communities, whereas species with narrower ecological amplitude (*Salsola monophera*) had lesser coenotic significance.

Sustainable use of pasture ecosystem resources depends on obtaining the most complete information about steppe vegetation. Pasture regime should be based on the landscape ecological approach with consideration given to pastures' feeding values and positions in the altitudinal zonal structure.

In order to preserve the invariant steppe communities and to restore steppe ecosystems, measures for improving of the steppe ecosystems should be developed. These measures should be also based on ecological principles that consider the ecosystems' position in vegetation structure of their altitudinal zones (mountains, hummocks, valleys, depressions) and in specific types of vegetation cover.

In this regard, published literature explores different measures aimed at improving floristic composition and structure of steppe ecosystems ensuring their sustainable development and functioning [Ecosystems…, 1995]. Among the proposed measures, in our opinion, the following activities will be most beneficial.

- Management of pasture use regime (schedule and duration of grazing and rotation);
- Regulation of grazing load (modeling of optimal livestock numbers and herd composition depending on the pasture type);
- Restoration of steppe ecosystems (incorporating "rest" of the steppe communities, improving feeding value of pasture by reseeding forage plants);
- Creation of grasslands to establish reserve stocks of feed;
- Organization of a monitoring system of steppes (multiyear observations of steppe plant communities and identification of fluctuations and succession stages);
- Identification and preservation of reserve areas of steppe ecosystems of different altitudinal zones to maintain the gene pool and replenishment of the seed pool of main species-forming steppe communities.

It is also necessary to continue work on developing the ecological framework of Eastern Mongolia for preservation of steppe ecosystems. A network of protected areas, including sanctuaries and a system of standard natural sites, should be developed. The network would link Mongolian steppes and the integrated system of protected areas of the Central Asian steppes, and the centers for biodiversity.

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