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SPATIAL STRUCTURE OF VEGETATION COVER OF SHARYN SNNP

The article presents the results of a study of the spatial structure of vegetation SNNP (State National Nature Park) «Sharyn» on the basis of the inventory and assessment of vegetation in SNNP «Sharyn» in Almaty region. The spatial distribution of the SNNP «Sharyn» vegetation cover was based on the landscape structure of the territory and ecological and physiognomic types of vegetation. The assessment of Botanical diversity of vegetation included an assessment of floral and phytocenotic diversity of vegetation. The floral diversity of the SNNP «Sharyn» vegetation cover consists of 915 species of vascular plants from 406 genera and 84 families, which indicates a significant species richness of the flora.

According to the Botanical and geographical division, the vegetation of the territory under consideration belongs to the Sahara-Gobi region, the Iran-Turan subdistrict, the Dzungarian province and belongs to the intermountain-basin deserts.

The taxonomic analysis of the flora of the SNNP «Sharyn» showed that the 10 leading families include 578 species, or 63.12% of the total number of species. The spatial heterogeneity of the vegetation cover of the SNNP «Sharyn» includes the vegetation of low-mountains, low-hills, foothill plains, arid-denudation plateaus, deluvial-proluvial plains, ancient alluvial plains, canyons and dry channels, valleys of the Temirlik and Sharyn rivers, anthropogenically disturbed agricultural lands.

The result of the assessment of the spatial distribution of vegetation cover was the creation of a vegetation map at a scale of 1: 300000. The created map contains 39 allotments.

Key words: Sharyn, floristic and phytocenotic diversity, inventory monitoring.
В статье приведены результаты исследования пространственной структуры растительного покрова ГНПП «Шарын» на основе инвентаризации и оценки состояния растительного покрова территории ГНПП «Шарын» в Алматинской области. Пространственное распределение растительного покрова ГНПП «Шарын» основывалось на ландшафтной структуре территории и эколого-физиономических типах растительности. Оценка ботанического разнообразия растительности ГНПП «Шарын» включала оценку флористического и фитоценотического разнообразия растительности. Флористическое разнообразие растительного покрова ГНПП «Шарын» составляют 915 видов сосудистых растений из 406 родов и 84 семейств, что указывает на значительное видовое богатство флоры.

Po ботанико-географическому делению растительность рассматриваемой территории относится к Сахаро-Гобийской области, Ирано-Туранской подобласти, Джунгарской провинции и относится к межгорно-котловинным пустыням.

Таксономический анализ флоры ГНПП «Шарын» показал, что 10 ведущих семейств включают 578 видов, или 63,12% от общего количества видов. Пространственная неоднородность растительного покрова ГНПП «Шарын» включает растительность низкогорий, мелкосопочников, предгорных равнин, аридно-денудационных плато, делювиально-пролювиальных равнин, древнеаллювиальных равнин, каньонов и сухих русел, долин рек Темирлик и Шарын, антропогенно нарушенных сельскохозяйственных земель.

Итогом оценки пространственного распределения растительного покрова было создание карты растительности масштаба 1:300000. Созданная карта содержит 39 выделов.

Ключевые слова: Шарын, флористическое и фитоценотическое разнообразие, инвентаризация, мониторинг.

Introduction

State National Natural Park «Sharyn» is located within the Ili intermountain basin. The central part of the basin is characterized by extremely arid rubble deserts of the Dzungarian type, which are Gobi analogs [1]. There is a deep-cut (50-120 m) canyon-shaped valley of the Sharyn River, a large left-bank tributary of the Ile River, whose sources are in the Kungey-Alatau mountains. The relict broad-leaved ash (Fraxinus sogdiana) forest has survived under the specific conditions of the canyon microclimate. Passing through the entire Eurasian chain of ranges of ash species, the ash species Fraxinus sogdiana naturally grows in Central Asia [2]. Among a wide range of terrestrial habitats, forests and woodlands are the richest, both biologically and genetically, due to their inherent structural and compositional complexity and diversity. While species composition is an important characteristic of biodiversity, forest structure may be even more relevant to biodiversity assessment, because a diversified structure is likely to have more niches, which in turn accommodate more species and facilitate more efficient use of available resources. Structure plays an important role as an indicator of diversity for management purposes, where maps of structural diversity of forests are very useful in planning conservation strategies. Airborne laser scanning data is a reliable and source of information for describing the three-dimensional structure of a forest [3]. Ecological networks can provide insight into how biodiversity loss and changes in species interactions affect the provision of ecosystem services [4]. There are 4 key areas for the conservation of forest biodiversity: the ability of species to survive in post-disturbed forest landscapes, the impact of plantation on biodiversity, the effectiveness of modified silvicultural systems on forest structure, vegetation composition and biota, and the relationship between deforestation and fire hazards [5]. High quality data on the occurrence of plant species are considered one
of the most important data sources for ecological research and conservation purposes. However, ecologically valuable fine-grained mosaics of dissimilar shrubs and herbaceous formations create a complex environment for creating distribution maps of such species. Remote sensing can be useful for such purposes, but it faces a number of problems, especially with the need to obtain ultra-high spatial resolution data and distinguish between plant species or genera [6].

The high botanical diversity of the territory is due to the position of the territory between the Kazakh and Dzungarian deserts, the influence of the Northern Tien Shan mountains and the presence of large river valleys (Ile, Sharyn).

According to the botanical-geographical zoning [1], the vegetation of the Ill depression belongs to the Sahara-Gobi desert botanical-geographical region, the Irano-Turan subregion, the Dzungar province within the middle deserts. The spatial structure of the habitat of plant communities based on soil functions includes the identification of the leading factors of biodiversity and the determination of the spatial heterogeneity of soil function. Therefore, the composition of plant communities (accuracy 95%) and a reference group of soils (accuracy 88%) were modeled depending on soil moisture conditions and used as a tool for spatial forecasting [7]. Land-use change requires measuring patterns of biodiversity change at different spatial scales to inform landscape management. Assessing changes in vegetation at different scales is challenging [8]. Research [9] describes a spatially structured, individual rangeland model that embodies this perspective and simulates the dynamics of forage and livestock production in semi-arid rangelands, using both continuous and alternating grazing. The ability to predict spatial variation in biodiversity is a long-standing but elusive goal of landscape ecology. It depends on a detailed understanding of the relationships between landscape and site structure and taxonomic richness, as well as accurate spatial modeling [10].

Bioclimatic substantiation of the spatial structure of vegetation based on the altitudinal division of vegetation using the global climate model. Statistical analysis showed differences between altitudinal belts, subbelts, and types of larch in terms of average annual temperature and average annual precipitation. The possibility of using climate as a factor of differentiation of vegetation cover at the regional level has been proven [11]. Spatial distribution patterns were determined using the Morisita overlap index for the species with the highest importance [12].

For the classification of ecosystems, the block structure of the system of water-terrestrial ecotones was used. Ecosystem mapping was based on an integrated approach that takes into account the patterns of plant distribution depending on the environment. For each block, a list of ecosystems was determined based on an assessment of species and phytocenotic diversity and environmental condition [13].

For each block, a list of ecosystems was determined based on an assessment of species and phytocenotic diversity and environmental conditions. Floristic features including floristic composition, life forms and aquatic plant ecotypes, floristic geographic elements were also evaluated [14].

Analysis of the current state of vegetation is an integral part of a comprehensive research program on landscape planning, which reveals the dynamics of vegetation, territorial differentiation, biological diversity, the degree of disturbance of the communities of the territory and the possibility of their preservation [15]. An indirect method for assessing biodiversity from Earth observations is the hypothesis of spectral variability. Spectral variability shows that the higher the spatial variability of the spectral response of an optical image with remote sensing, the greater the number of accessible ecological niches and, therefore, the higher the biodiversity in the considered area [16].

Measurements of the spatial structure and Botanical diversity of vegetation SNNP «Sharyn» is performed on the basis of the field work of the authors on the territory 2016, 2017, 2019, 2020, drawing on the materials of the herbarium of Institute of botany and Phytointroduction of MES RK, Center for Remote sensing and GIS “Terra” (2008) [17] and the work of the scientific Department of SNNP «Sharyn». Still, the relative importance of environmental and spatial factors in shaping the structure of local plant diversity remains unclear.

The aim of this research was to identify the spatial structure of vegetation SNNP «Sharyn» on the basis of the inventory and assessment of vegetation in SNNP «Sharyn». Inventory, monitoring and analysis of the Botanical diversity of a specific territory is the scientific basis for nature protection.

Objects of research: vegetation cover of the territory of SNNP “Sharyn”, its composition, structure, spatial distribution, anthropogenic disturbance

Methods of research: vegetation cover was studied using traditional geobotanical research methods «Field geobotany...,1959-1976» [18]
Field mapping was performed using the route method using a GPS device to determine coordinates. At the same time, the selected points in the descriptions, which reflect the diversity of landscapes and PTC in the study area, described in detail the components of the landscape (topography, soil, vegetation, etc.) and their condition.

**Floristic diversity of vegetation cover of the SNNP «Sharyn»**

**Taxonomic analysis**

According to literature data, the flora of the park numbers about 1000 species of plants, of which 51 are rare and endemic.

Current research for 2016-2020 shows that the floral diversity of the vegetation cover of the SNNP «Sharyn» consists of 915 species of vascular plants from 406 genera and 84 families, which indicates a significant species richness of the flora.

Taxonomic analysis of the flora of the SNNP «Sharyn» showed that the first 10 families include 578 species, or 63.12% of the total number of species (Table 1).

**Table 1 – The number of species in the 10 leading families of the flora of the SNNP «Sharyn»**

| №  | FAMILIES                        | Number of species | %    |
|----|--------------------------------|-------------------|------|
| 1  | Asteraceae Dumort – Asteraceae  | 128               | 13.98|
| 2  | Poaceae Barnhart – Poaceae      | 83                | 9.07 |
| 3  | Fabaceae Lindl. – Pea family   | 74                | 8.08 |
| 4  | Chenopodiaceae Vent – Goosefoot family | 72 | 7.86 |
| 5  | Brassicaceae Barnett – Crucials | 65                | 7.10 |
| 6  | Rosaceae Juss – Rose family     | 45                | 4.91 |
| 7  | Lamiaceae Lindl. – Mint family | 34                | 3.71 |
| 8  | Boraginaceae Juss. – Heliotropes| 29                | 3.17 |
| 9  | Ranunculaceae Juss. – Crowfoot family | 25 | 2.73 |
| 10 | Cyperaceae Juss. – Cyperaceae   | 23                | 2.51 |
| 11 | Number of species in the top 10 families | 578 | 63.12 |
| 12 | Total species in the flora of the SNNP «Sharyn»: | **915** | **100%** |

The sequence of the most multi-species families is as follows: Asteraceae (128), Poaceae (83), Fabaceae (74), Chenopodiaceae (72), Brassicaceae.
(65), Rosaceae (45) Lamiaceae (34), Boraginaceae (29) Ranunculaceae (25), Cyperaceae (23).

The number of the largest families, including from 55 to 5 genera is 15 (table 2). They contain 306 genera of the entire flora of SNNP «Sharyn», or 75% of all genera.

The largest genera, including 10 to 26 species, are: the next 10 genera: Astragalus (26 species), Artemisia (18), Allium (17), Carex, Potentilla (14 species), Euphorbia (12), Salix, Veronica (11 species), Salsola, Stipa (10 species).

Further from 9 to 5 species contain the following 32 genera: Oxytropis, Tulipa (9 species); Taraxacum, Rosa (8 species); Lappula, Iris, Zygophyllum (7 species); 8 genus (Ferula, Centaurea, Silene and etc.) contains 6 species; 17 genus (Atriplex, Erysimum, Scorzonera and etc.) – 5 species.

There are 26 families of monotypic families containing one genus, one species in the flora of SNNP «Sharyn».

### Table 2 – The number of genera in large families of the flora of SNNP «Sharyn»

| №  | Families                      | Number of genera |
|----|------------------------------|------------------|
| 1  | Asteraceae Dumort. – Asteraceae | 55               |
| 2  | Poaceae Barnhart – Poaceae    | 48               |
| 3  | Brassicaceae Barnett – Crucials | 41              |
| 4  | Chenopodiaceae Vent – Goosefoot family | 32       |
| 5  | Fabaceae Lindl. – Pea family  | 20               |
| 6  | Apiaceae Lindl. – Parsley family | 16             |
| 7  | Lamiaceae Lindl. – Mint family (Labiatae) | 16         |
| 8  | Rosaceae Juss. – Rose family  | 16               |
| 9  | Boraginaceae Juss. – Heliotropes family Boraginaceae | 14            |
| 10 | Caryophyllaceae Juss. – Pink family | 11             |
| 11 | Ranunculaceae Juss. – Crowfoot family | 11         |
| 12 | Polygonaceae Juss. – Buckwheat family | 10         |
| 13 | Crassulaceae DC. – Orpine family | 6              |
| 14 | Scrophulariaceae Juss. – Figwort family | 6          |
| 15 | Cyperaceae Juss. – Cyperaceae  | 5                |
| 16 | Total genera in 15 families  | 307              |
| 17 | Total species in the flora of the SNNP «Sharyn» | 406           |

**Rare species**

The uniqueness and originality of the flora of a particular territory is determined by the presence of rare and endemic plants. There are 39 species listed in the Red Book of the Republic of Kazakhstan on the territory of the SNNP «Sharyn» (Table 3). Among them: *Aquilegia vitalii* Gamajun., *Arthrophytum iliense* Iljin, *Berberis iliensis* M.Pop., *Chesneya dshungarica* Golosk., *Crocus alatavicus* Regel et Semen, *Ferula iliensis* Krasn.ex Korov., *Ferula sjugatensis* Bjat, *Ikonnikovia Kaufmanniana* (Regel) Lincz, *Lonicera iliensis* Pojark., *Plagiobasis centauroides* Schrenk, *Populus pruinose* Schrenk, *Tulipa alberti* Regel, etc. At the limit of the range grow *Iljinia regelii* Bunge, *Simpegma regelii* Bunge and others.

### Table 3 – Species of the SNNP «Sharyn» listed in the Red Book of the Republic of Kazakhstan

| №  | Species                                      |
|----|----------------------------------------------|
| 1  | *Aquilegia vitalii* Gamajun.                 |
| 2  | *Armeniaca vulgaris* Lam.                    |
| 3  | *Arthrophytum iliense* Iljin                 |
| 4  | *Astragalus tscharynensis* M.Pop.            |
| 5  | *Berberis iliensis* M.Pop.                   |
| 6  | *Celtis caucasica* Wild.                     |
| 7  | *Centaurea turkestanica* Franch.             |
| 8  | *Chesneya dshungarica* Golosk.               |
| 9  | *Crataegus korolkowii* LHenry                |
| 10 | *Crocus alatavicus* Regel et Semen           |
| 11 | *Ferula iliensis* Krasn.ex Korov.            |
| 12 | *Ferula sjugatensis* Bjat.                   |
| 13 | *Fraxinus sodiana* Bunge                     |
| 14 | *Fritillaria pallidiflora* Schrenk           |
| 15 | *Haplophyllum dshungaricum* Rubtz.           |
| 16 | *Heliotropium parvulum* M.Pop.               |
| 17 | *Hepatica falconeri* (Thoms) Steward         |
| 18 | *Ikonnikovia Kaufmanniana* (Regel) Lincz     |
| 19 | *Iris alberti* Regel                         |
| 20 | *Juniperus chinensis* (B.Fedtsch) Poljak.    |
| 21 | *Lepechiniella michaelis* Golosk.            |
| 22 | *Limonium michelsonii* Lincz.                |
| 23 | *Lonicera iliensis* Pojark.                  |
| 24 | *Malus sieversii* (Lede.) M.Roem.            |
| 25 | *Oxytropis almatensis* Bajt.                 |
| 26 | *Oxytropis niedzwetziana* M.Pop.             |
| 27 | *Paeonia hybrida* Pall.                      |
| 28 | *Plagiobasis centauroides* Schrenk           |
| 29 | *Populus pruinose* Schrenk                   |
| 30 | *Rheum wittrockii* Lundstr.                  |
| 31 | *Rhodiola rosea* L.                         |
| 32 | *Serratula dshungarica* Iljin                |
| 33 | *Stipa kungeica* Golosk.                     |
| 34 | *Stroganovia sagittata* Kar. et Kir.         |
| 35 | *Tulipa alberti* Regel                       |
| 36 | *Tulipa brachystemon* Regel                  |
| 37 | *Tulipa kolpakovskiana* Regel                |
| 38 | *Tulipa patens* Agardh & Schult.             |
| 39 | *Tulipa uniflora* (L.) Bess.ex Baker.        |
On the territories of SNNP «Sharyn» grow 39 species listed in the Red book of the Republic of Kazakhstan.

Phytocenotic diversity of vegetation cover of the SNNP «Sharyn»

According to the Botanical and geographical division, the vegetation of the territory under consideration belongs to the Sakhar-Gobi region, the Iran-Turan subdistrict, the Dzungarian province and belongs to the intermountain-basin deserts.

The following types of vegetation are found on the territory of the Sharyn state Park: steppe, desert, shrub, meadow, swamp, and tugai. The diversity of landscapes and belonging to the ili basin, which is the «enclave of the Dzungarian deserts», determines the unique combination and diversity of vegetation cover. The spatial heterogeneity of the vegetation cover of the Sharyn national Park includes vegetation of low mountains, small hills, foothill plains, arid-denudation plateaus, deluvial-proluvial plains, ancient alluvial plains, canyons and dry channels, valleys of the Temirlik and Sharyn rivers, and anthropogenic disturbed agricultural lands.

The range of zoning on the plains is characterized by a change of desolate steppes on light chestnut soils (1400-1500 m), settled deserts on brown soils (1200-1400 m) and real deserts on gray-brown soils (700-1200), extremely arid deserts (600-700 m) are represented fragmentally in the lower part. The altitudinal zone structure of vegetation distribution in low mountains and mountains includes: mountain desolate steppes, mountain desolate steppes, dry steppes. The Central, lowest part of the basin is occupied by fragments of extreme arid deserts. It is characterized by a combination of stony gammads, devoid of vegetation, with iljinia (Iljinia regelii) communities on the sayam. Real deserts on gray-brown soils occupy the largest territory in terms of length and amplitude of heights (700-1200 m). Desolate steppes on light chestnut soils and settled deserts (semi-deserts) on brown soils are common in the high part of the territory adjacent to the mountains. The surveyed territory is dominated by the ecological and physiognomic type of perennially saline deserts: tasbyyurgunovye deserts (Nanophyton erinaceum) with subtypes: pure tasbyyurgun, feather grass-tasbyyurgun (Nanophyton erinaceum, Stipa caucasia, S. orientalis), saxaulchik-tasbyyurgun (Nanophyton erinaceum, Arthrophytum iliense), biyurgun-tasbyyurgun communities (Nanophyton erinaceum, Anabasis salsa), Salsola (Salsola arbusculiformis) common only in high hills and low mountains.

In real deserts on gray-brown soils, tasbyyurgun-salsola are common (Salsola arbusculiformis, Nanophyton erinaceum), wormwood-salsola communities (Salsola arbusculiformis, Artemisia sublessingiana). The belt of steppe deserts on mountain brown soils is characterized by the predominance of species rare in composition and floristically rich hawksers: cereal-boalychka (Salsola arbusculiformis, Stipa macroglossa, S. orientalis, Agropyron cristatum), cereal-tasbyyurgun-salsola (Salsola arbusculiformis, Nanophyton erinaceum, Convolvulus tragacanthoides, Stipa orientalis, Cleistogenes songorica), shrub-feather-grass-salsola (Salsola arbusculiformis, Atraphaxis replicata, Caragana kirghisorum, Stipa orientalis, Cleistogenes songorica), злаково-mulitherb-karagana-salsola (Salsola arbusculiformis, Caragana kirghisorum, Ikonnikovia kaufmanniania, Allium galanthum, Stipa macroglossa, S. orientalis, Agropyron cristatum).

Arid-denudation plateaus are characterized by gray-brown gypsum-bearing soils and saxaulchik (Arthrophytum iliense, A. longibracteatum) deserts. On the territory of the SNNP «Sharyn» there is a series of rare perennial saxaul communities: Suaeda dendroides, Iljinia regelii, Reaumuria songarica, Sympegma regelii.

Among the wormwood deserts, we should mention the Semirechye wormwood (Artemisia heptopota
tamica) on foothill brown soils. Particularly widespread are the cereal-semirechensky wormwood (Artemisia heptapotamica, Stipa sareptana, Festuca valesiaca, Agropyron cristatum, Kochia prostrata) communities. Sublessingiana-wormwood (Arte-
misia sublessingiana) communities are found on gravelly-fine earth, usually on the northern slopes of the hummocks. Wormwoods (Artemisia santolina) are a common type of communities on saline sands. The saxaul-santal wormwood (Artemisia santolina, Haloxylon aphyllum) and the rheumurian-santal wormwood (Artemisia santolina, Reomuria songarica) communities are widespread. White earth wormwood (Artemisia terrae-albae) rarely wind and are associated mainly with soils of light texture.

The composition of the communities on the sands is peculiar. Thus, for mixed saxaul (Haloxylon aphyllum, H. persicum) communities of sands with a close occurrence of groundwater, the participation of meadow plants and tugai species is characteristic (Halomodendron halodendron, Phragmites australis). Sand-acacia-saxaul (Haloxylon persicum Anmodendron bifolium) deserts are found in small areas along the tops of sandy ridges, as well as psammophytic shrubs (Calligonum junceum) – a rare type of communities, also confined to the wav-
Spatial structure of vegetation cover of Sharyn SNNP

The developed map reflects modern vegetation. The map shows both the poster and the entire spectrum of non-poster communities. Both typological and horological mapped vegetation units were used to reflect the heterogeneous spatial structure of vegetation cover on the «SNNP «Sharyn» vegetation Map M 1:300000».

Map legend consists of a subtitle system. The subheadings reflect the high-level connection with the high tiers of relief. In the legend to the map of vegetation of the SNNP «Sharyn», the following are highlighted: low mountains, small hills, foothill plains, intermountain basin (including arid-denudation plateaus, deluvial-proluvial plains, ancient alluvial, canyons and dry channels), modern alluvial plains (Sharyn river valley).

Along with the homogeneous homogeneous units of vegetation – fotocamere (groups, communities, or associations) as mapped units for heterogeneous cover of the widely used types pirozenko (complexes, series, aggregate, and combinations of series, environmental series, etc.), allowing to emphasize the characteristic of SNNP «Sharyn» spatial heterogeneity of vegetation.

The map legend contains 39 selections. The drawing on the map is highlighted in color and texture. Solid color shows the vegetation of the mountains, the low hills, and Piedmont plains etc. The texture shows the spatial differentiation of specific selections. The floral diversity of vegetation of the SNNP «Sharyn» has been clarified. At the moment, it consists of 915 species of vascular plants from 406 genera and 84 families. There are 39 species of red book species on the territory of the Sharyn state farm.

Phytocenotic diversity includes seven types of vegetation (swamp, water, meadow, forest, shrub, steppe, desert). The spatial structure of the created vegetation cover map includes the following divisions: low mountains, small hills, foothill plains, intermountain basin (including arid-denudation plateaus, deluvial-proluvial plains, ancient alluvial, canyons and dry channels), modern alluvial plains (Sharyn river valley).

Vegetation map SNNP «Sharyn»

The following maps were used for the analysis of cartographic materials on Botanical diversity: vegetation Map of Kazakhstan and Central Asia (within the desert region) M 1:2500000, forage land Map of the Kazakh SSR M 1: 2000000, vegetation Map for the national Atlas of the Republic of Kazakhstan M 1:7000000, landscape map and Ecosystem Map created during the compilation Center for Remote sensing and GIS Terra.

When creating the vegetation map of the SNNP «Sharyn» M 1:300 000, the methodology and
methods developed for the cartographic assessment of vegetation in various regions were taken into account. When drawing up the vegetation map of the SNNP «Sharyn», it was assumed that it should reveal the regularities of the structure of vegetation cover associated with the differentiation of environmental conditions. Variegated vegetation cover, due to the heterogeneity of the physical and geographical environment and various degrees of anthropogenic transformation of vegetation, is particularly pronounced at the SNNP «Sharyn».

The developed map reflects modern vegetation. The map shows both the placard and the entire spectrum of non-placard communities. Both typological and horological mapped vegetation units were used to reflect the heterogeneous spatial structure of vegetation cover on the «SNNP «Sharyn» vegetation Map M 1:300 000». Map legend consists of a subtitle system. The subheadings reflect the high-level connection with the high tiers of relief. In the legend to the map of vegetation of the SNNP «Sharyn», the following are highlighted: low mountains, small hills, foothill plains, intermountain basin (including arid-denudation plateaus, deluvial-proluvial plains, ancient alluvial, canyons and dry channels), modern alluvial plains (Sharyn river valley) [30].

Along with the homogeneous units of vegetation – fotocamere (groups, communities, or associations) as mapped units for heterogeneous cover of the widely used types pirozenko (complexes, series, aggregate, and combinations of series, environmental series, etc.), allowing to emphasize the characteristic of SNNP «Sharyn» spatial heterogeneity of vegetation.

The map legend contains 39 selections. The drawing on the map is highlighted in color and texture. Solid color shows the vegetation of the mountains, the low hills, and Piedmont plains etc. The texture shows the spatial differentiation of specific selections.

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**Cover story to SNNP «Sharyn» vegetation Map 2016 year**

| No apportionment | Color and texture | Content |
|------------------|-------------------|---------|
| VEGETATION OF LOW MOUNTAINS |
| (**Helictotrichon desertorum**, Stipa zalesskii, Festuca valesiaca, Agropyron cristatum, Dracocephalum integrifolium Cotoneaster melanocarpus, Lonicera hispida) steppes on mountain low-power chestnut soils in combination with shrubby thickets (**Rosa plathycantha**, Spiraea lasiocarpa, **Rosa alberti**, Lonicera albertii) on mountain meadow-chestnut soils on the logs of rocky-hilly and low mountains |
| (Festuca valesiaca Artemisia heptapotamica, Artemisia sublessingiana) steppes on mountain light chestnut soils, combined with (Stipa orientalis, Artemisia rutifolia, Allium galanthum, A.senescens) the coenosis on mountain light chestnut underdeveloped and primitive soils and rocks of the hilly ridge of low mountains |
### Spatial structure of vegetation cover of Sharyn SNNP

#### Table continuation

| № apportionment | Color and texture | Content |
|-----------------|-------------------|---------|
|                 |                   | (Salsola arbusculiformis, Stipa orientalis, S. macroglossa, Caragana kirghisorum) communities on mountain brown stony-gravelly soils on the upper parts in combination with grasses-saline (Helianthemum soongarica, Stipa orientalis), (Convolvulus tragacanthoides, Stipa caucasica) cenoses on mountain brown primitive soils and rock outcrops on the slopes of rocky strongly dissected low mountains |

#### THE VEGETATION OF THE HUMMOCKS

|                 |                   | (Caragana kirghisorum, Ephedra intermedia, Ephedra distachya) on grey-brown soils of undeveloped and stony soils of peaks and upper parts of slopes in combination with (Salsola arbusculiformis, Nanophyton erinaceum, Anabasis truncata, Artemisia sublessingiana, A. heptapotamica) on (Convolvulus tragacanthoides, Convolvulus gortshakovi, Helianthemum soongoricum) communities on grey-brown shallow soils of rocky slopes and hilly |
|                 |                   | (Anabasis truncata) on rocky peaks, (Salsola arbusculiformis) on grey-brown undeveloped and underdeveloped soils, (Salsola arbusculiformis, Artemisia sublessingiana) on grey-brown shallow soils fine-knoll hilly |
|                 |                   | (Artemisia sublessingiana) on (Nanophyton erinaceum, Artemisia heptapotamica) the gray-brown featuring poorly developed soils of the low uplands |

#### VEGEATION OF FOOTHILL PLAINS

|                 |                   | (Artemisia heptapotamica, Stipa orientalis) on brown low-power soils in combination with (Nanophyton erinaceum, Stipa caucasica) on brown uniformed and primitive soils on the foothill plain |
|                 |                   | (Nanophyton erinaceum) on grey-brown low-power gravelly-pebble soils in combination with (Artemisia terrae-albae, Stipa orientalis) communities on meadow-brown soils of dry streams of the foothill plain |
|                 |                   | (Nanophyton erinaceum) the gray-brown loam and schebnisto-dresvyanskii soils in combination with (Salsola arbusculiformis) and karahanovym the say on the sloping Piedmont plain |

#### VEGEATION OF THE INTERMOUNTAIN BASIN

#### VEGEATION OF ARID-DENUDATION PLATEAUS

|                 |                   | (Arthrophytum ihense) on gray-brown gypsum-bearing low-power loamy soils of the arid-denudation plateau |
|                 |                   | (Arthrophytum ilicis, Nanophyton erinaceum) community to grey-brown weakly gypsum soils and (Arthrophytum ilicis) deserts on gray-brown gypsum-bearing. soils in combination with perennially saline (Salsola orientalis, Salsola arbusculiformis, Arthrophytum ilicis) communities on the sayam arid-denudation plateau |
|                 |                   | (Arthrophytum ihense) on gray-brown washed-out gypsum-bearing loamy pebbly-gravelly soils (Haloxylon aphyllum, Salsola orientalis) and (Haloxylon aphyllum, Ephedra lomatolepis) on meadow-brown soils of arid-denudation plateaus |
|                 |                   | (Nanophyton erinaceum, Arthrophytum ilicis) on gray-brown low-power (Arthrophytum ilicis) gypsum-bearing loamy gravelly-woody soils of arid-denudation plateaus |
|                 |                   | (Suaeda dendroides, S. microphylla, Salsola orientalis, Reaumuria soongorica) communities on gray-brown saline gypsum-bearing soils of arid-denudation plateaus |

#### VEGEATION OF DELUVIAL-PROLUVIAL PLAINS

|                 |                   | (Nanophyton erinaceum) and (Artemisia heptapotamica) communities on gray-brown shallow and normal soils in combination with (Artemisia terrae-albae, Krascheninnikovia ceratoides) on meadow-brown soils of temporary watercourses on a gently sloping deluvial-proluvial plain |
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Table continuation

| № apportionment | Color and texture | Content |
|------------------|-------------------|---------|
|                  |                   | (Suaeda dendroides, S. microphylla, Reaumuria soongorica, Salsola orientalis) communities on gray-brown saline gypsum-bearing soils in combination with (Haloxylon aphyllum) on meadow-brown soils along the slopes of a gently sloping deluvial-protuvial plain |
|                  |                   | (Suaeda dendroides, Suaeda microphylla, Arthrophytum iliense) communities on gray-brown gypsum-bearing eroded soils of gently sloping deluvial-protuvial plain |
|                  |                   | (Nanophyton erinaceum) communities on gray-brown normal and shallow soils in combination with (Arthrophytum iliense, A. longibracteatum) on gray-brown slightly gypsum-bearing rubble-pebble loamy soils of gently sloping deluvial-protuvial plain |
|                  |                   | (Nanophyton erinaceum, Arthrophytum iliense) on gray-brown gypsum-bearing loamy rubble-pebble soils in combination with (Nanophyton erinaceum, Anabasis salsa) on the salt licks of the gently sloping deluvial-protuvial plain |

VEGETATION OF ANCIENT ALLUVIAL PLAINS

Complex of (Haloxylon aphyllum) and (Artemisia terrae-albae, Salsola orientalis) on takyr-like soils with an eolian mantle in combination with takyrs without vegetation on the ancient alluvial accumulative plain

VEGETATION OF EXTREME ARID PLAINS

Single plants Iljinia regelii, Arthrophytum longibracteatum, A. iliense on extremely arid loamy-pebble-gravelly deposits of a rocky gamma of gently sloping weakly dissected plains

(Nanophyton erinaceum) and (Arthrophytum longibracteatum, A. iliense) on extremely arid gravelly-gravelly soils of gentle undulating plains in combination with shrub (Caragana balchashensis, Athraphaxis replicata, Ephedra intermedia, Acanthophyllum pungens, Salsola arbuscula, Convolvulus gortshakoviicommunities on meadow-brown soils along the say

(Arthrophytum longibracteatum, A.iliense) and (Salsola orientalis) communities on extremely arid pebble-gravelly soils of undulating-ridged dissected plains

THE VEGETATION OF THE CANYONS AND DRY RIVERBEDS

THE VEGETATION OF THE CANYONS

(Sabola arbuscliformis), (Sabola arbuscliformis, Nanophyton erinaceum), (Nanophyton erinaceum) and (Anabasis truncata, A.eriopoda) communities on gray-brown primitive gravelly-stony soils of canyon slopes combined with (Caragana balchashensis, Athraphaxis replicata) on meadow-brown poorly developed soils of stony logs

(Sabola arbuscliformis, Nanophyton erinaceum), (Sabola arbuscliformis, Ephedra intermedia) communities on grey-brown gravelly-stony soils combined with shrubs and semi-shrubs (Ephedra intermedia, Caragana balchashensis, Nanophyton erinaceum) over rocks and shrubs (Caragana balchashensis, Athraphaxis spinosa, A decepiens) along the logs in the rocky hillock

Sparse factions involving (Ephedra intermedia, E. equisetina, Athraphaxis decipiens, Caragana kirghisorum, Convulvulus tragacanthoides, Salsola arbuscliformis, Artemisia rutifolia, A. juncea, A. sublessingiana, Brachanthemum titovi, Nanophyton erinaceum) on the rocky sides of the canyon

(Populus diversifolia, Panigra, Salix kirilovii, Rosa iliense, Trachomitum lancifolium, Clematis orientalis) on primitive alluvial meadow-tugai soils along the channel and shrub thickets (Rosa plathyacantha, R. silverhjelmi, Berberis iliensis Lonicera iliensis, Clematis songarica) on primitive alluvial meadow soils of the first floodplain terrace in combination with single shrubs (Athraphaxis virgata, Caragana kirghisorum, Ephedra intermedia, Salsola arbuscula) rocky steep slopes
Spatial structure of vegetation cover of Sharyn SNNP

| № | Color and texture | Content |
|---|------------------|---------|
|  |                  | **VEGETATION OF DRY RIVERBEDS** |
|  |                  | Complex communities: (Haloxylon aphyllum, Salsola arbuscula, Salsola orientalis) and (Artemisia terrae-albae, Ephedra intermedia) on alluvial-proluvial deposits of bottoms in combination with settlements of shrubs (Ephedra intermedia, Atraphaxis decipiens, Caragana kirghisorum, Convolvulus tragacanthoides) on the steep slopes of dry channels of temporary watercourses |
|  |                  | Complex communities: (Arthrophytum iliense), (Salsola orientalis) Artemisia terrae-albae-albae, Ephedra intermedia) with Haloxylon aphyllum on the outcrop of the ancient alluvial-lacustrine deposits (Artemisia terrae-albae-albae, Convolvulus gortshakovi) gray-brown uniformed soils by say |
|  |                  | **VEGETATION OF RIVER VALLEYS** |
|  |                  | A number of communities: (Tamarix ramosissima, Alhagi pseudalhagi, Phragmites australis) → (Tamarix ramosissima, Karelinia caspica) → (Haloxylon aphyllum, Salsola orientalis) on meadow-brown soils of dry channels of temporary watercourses |
|  |                  | A number of communities: (Artemisia terrae-albae-albae, Acanthophyllum pungens, Ferula iliensis) → (Caragana balchashensis, Atraphaxis replicata) (Salsola arbuscula, Ephedra intermedia, Calligonum juncceum, Convolvulus gortshakovii) on the sandy loam-sandy soils with desvanace-gravelly inclusions of streams and dry river beds of temporary streams |
|  |                  | **VEGETATION OF THE SHARYN FLOODPLAIN** |
|  |                  | A number of communities: sparse groupings (Chenopodium botrys, Chondrilla ambigua, Cryptis schoenoides, Mentha arvensis, Xanthium strumarium) on shingle shallows on primitive alluvial-meadow soils → grass-grass meadows (Phragmites australis, Calamagrostis epigeios, Glycyrrhiza uralensis, Trachomitum lanacifolium) on alluvial-lute soils → grasslands of different grasses (Vexibia alopecuroides, Leymus multicaulis) with groups of trees (Salix songarica, Elaeagnus oxycarpa) on meadow-tugai soils of a low floodplain |
|  |                  | A number of communities: (Fraxinus sogdiana) with sparse groupings of Asparagus officinalis и Ribes saxatile → (Elaeagnus oxycarpa, Salix angustifolia, Palba) with a shrub layer of (Rosa ilicis, Lonicera ilicis, Berberis ilicis) → (Elaeagnus oxycarpa, Salix alba, Skirillovii, Hippophae rhamnoides, Clematis orientalis) on alluvial tugai soils of low floodplains and river banks |
|  |                  | A number of communities: (Elaeagnus oxycarpa, Salix alba, S. songorica, Tamarix ramosissima, Hippophae rhamnoides) with single (Fraxinus sogdiana) → (Fraxinus sogdiana) → (Populus diversifolia, P. pruinosus, Fraxinus sogdiana) with a shrub layer of (Berberis ilicis, Tamarix ramosissima) → Haloxylon aphyllum on alluvial-meadow soil is presented of the high floodplain |
|  |                  | A number of communities: (Elaeagnus oxycarpa, Salix michelsooni, S.songarica, Tamarix ramosissima, Clematis orientalis) – (Glycyrrhyza glabra, Leymus multicaulis, Calamagrostis epigeios) → (Populus diversifolia, P.pruinosus, Berberis ilicis, Tamarix ramosissima, Reamuria songorica) → (Tamarix ramosissima, Halimodendron halodendron, Nitraria sibirica, Ceratozoides papposa) → (Kalidium schrenkianum, Tamarix hispida, Achatherum splendens, Limonium gmelinii) on alluvial-meadow dried soils with signs of salinity and meadow salt marshes of high floodplain |
|  |                  | **VEGETATION OF THE ABOVE-FLOODPLAIN TERRACES OF SHARYN** |
|  |                  | A number of communities: (Populus pruinosus, P.diversifolia) with the participation of (Fraxinus sogdiana) with (Kalidium foliatum, K schrenkianum, Halostachys belangriana, Nitraria sibirica, Limonium gmelinii) on the salt marshes of meadow → shrub (Tamarix hispida, Tramoxissima, Atraphaxis spinosa, Apyrifolia, Krascheninnikovia ceratozoides) on meadow-brown soils of above-floodplain terraces |
Table continuation

| № apportionment | Color and texture | Content |
|-----------------|-------------------|---------|
| 3               | (Kalidium schrenkianum, Tamarix hispida, Tamarix ramosissima, Achnatherum splendens) community in combination with planting of tree species (Elaeagnus oxycarpa) and (Ulmus pumila) on salt marshes of meadow and secondary floodplain terraces |

ANTHROPOGENIC TRANSFORMED VEGETATION

Agricultural land

Conclusion

Taxonomic analysis of the floral diversity of the plant cover of the SNNP «Sharyn» showed that 915 plant species and 406 genera were identified in the flora. The species of the Asteraceae Dumort. family – Aster, which is 13.98%, and Poaceae Barnhart species – Cereals 9.07% and 8.08% -Fabaceae Lindl. – Legumes-dominate. There are 39 species listed in the Red Book of the Republic of Kazakhstan.

The phytocenotic diversity of the plant cover of the SNNP «Sharyn» was determined. The following types of vegetation are found on the territory: steppe, desert, shrub, meadow, swamp, and tugai.

An assessment of the spatial structure of the vegetation cover of the SNNP «Sharyn» was made, and a vegetation map of the SNNP «Sharyn» was created, in which 39 natural contours were marked. The map contains 13 vegetation sections: vegetation of low mountains, small hills, foothill plains, intermountain basins, deluvial-proluvial plains, ancient alluvial plains, extreme arid plains, canyons and dry channels, river valleys, floodplains of Sharyn, above-floodplain terraces of Sharyn, as well as anthropogenic transformed vegetation.

References

1 Rachkovskaya Ye.I., Rastitel’nost’ gobiyskikh pustyn’ Mongolii. [Vegetation of the Gobi Deserts of Mongolia.] p -135. SPb.: Nauka,1993.
2 Drenkhan, R., Adamson, K., Hanso, M. “Fraxinus sogdiana, a Central Asian Ash Species, Is Susceptible to Hymenoscyphus fraxineus”. Plant Protection Science. Vol. 51, no 3, (2015): 150-152.
3 Matteo, Mura, Ronald E., McRoberts, Gherardo, Chirici, Marco, Marchetti. “Estimating and mapping forest structural diversity using airborne laser scanning data”. Remote Sensing of Environment. Vol 170, (2015.): 133-142.
4 Philpott, S.M., Lucatero, A., Bichier, P., Egerer, MH., Jha, S., Lin, B., Liere, H. “Natural enemy-herbivore networks along local management and landscape gradients in urban agroecosystems”. Ecological Applications. https://doi.org/10.1002/ eap.2201.23.06.2020.
5 Lindenmayer, D.B. “Landscape change and the science of biodiversity conservation in tropical forests: A view from the temperate world”. Biological Conservation. Vol. 143, no 10. (2010.): 2405-2411.
6 Lozbenev, N., Smirnova, M., Bocharnikov, M., Kozlov, D. “Digital Mapping of Habitat for Plant Communities Based on Soil Functions: A Case Study in the Virgin Forest-Steppe of Russia”. Soil Systems. vol. 3, no 1. (2019): 1-12.
7 Prosek, J., Simova, P. “UAV for mapping shrubland vegetation: Does fusion of spectral and vertical information derived from a single sensor increase the classification accuracy?” International Journal of Applied Earth Observation and Geoinformation. Vol. 75, (2019.):151-162.
8 Egerer, M.H., Wagner, B., Lin, B.B., Kendal, D., Zhu, K. “New methods of spatial analysis in urban gardens inform future vegetation surveying”. Landscape Ecology, vol. 35, no 3, (2020): 761-778.
9 Wang, H.H., Grant, W.E., Teague, R. “Modeling rangelands as spatially-explicit complex adaptive systems”. Journal of Environmental Management. 110762 (2020.):269.
10 Grafius, D.R., Corstanje, R., Warren, P.H., Evans, K.L., Norton, B.A., Siriwardena, G.M., Pescott, O.L., Plummer, K.E., Mears, M., Zawadzka, J. “Using GIS-linked Bayesian Belief Networks as a tool for modelling urban biodiversity”. Landscape and Urban Planning, vol.189, (2019), 382-395.
11 Bocharnikov, M.V., Stas’ko, A.A. “Spatial structure of the Kodor-Kalar orobiome botanical diversity on bioclimatic basis”. Edp Sciences. Vol. 11, doi.org/10.1051/bioconf/20181100007, (2018): 1-4.
12 dos Santos, R.O., Lima, R.C., de Lima, R.B., Aparicio, P.D., de Abreu, J.C. “Floristic and structure of a community arboreal in forest state of Amapa, Eastern Amazon, Brazil”. Nativa: Pesquisas Agrárias e Ambientais. Vol. 5, (2017): 529-539.
13 Dimeyeva, L.A., Sitpayeva, G.T., Ussen, K., Sultanova, B.M., Permentina, V.N., Sadvokasov, R.E., Nurashov, S.B., Sametova, E.S. “Mapping of the ecosystems of the littoral ecotone in the Ural River Delta and in the Caspian Sea”. Acta Zoologica Bulgarica. No 11, (2020): 133-138.

14 Yuanjun, Zhu., Dan, Shan., Baizhu, Wang., Zhongjie, Shi., Xiaoai, Yang., Yanshu, Liu. “Floristic features and vegetation classification of the Hulun Buir Steppe in North China: Geography and climate-driven steppe diversification”. Global Ecology and Conservation. Vol. 20, e00741. (2019.):1-28.

15 Novitskaya, N.I., Suvorov, E.G. “Preservation of the natural potential of vegetation. Assessment in landscape planning”. International scientific and Practical conference in commemoration of corr. mem., ras, A.N. Antipov Geographical foundations and Ecological principles of the regional policy of nature management. vol. 381, doi:10.1088/1755-1315/381/1/012090 (2019):1-5

16 Torresani, D., Rocchini, D., Sonnenschein, R., Zebisch, M., Hauffe, H.C., Heym, M., Pretzsch, H., Tonon,G. “Height variation hypothesis: A new approach for estimating forest species diversity with CHM LiDAR data”. Ecological Indicators. Vol. 117, no 106520, (2020). https://doi.org/10.1002/ecy.2109.

17 Yestestvenno-nauchnoye obosnovaniye rasshireniya Sharynskogo GNPP. [Natural-scientific substantiation of the expansion of the Sharyn GNPP]. Proyekt Pravitelstva RK, Utverzhdeno prikazom Ministerstvo sel'skogo khozyaystva RK. n: 49 Rukovoditel’ N.P. Ogar’. 2008.

18 Polevaya geobotanika. [Field geobotany.] v.1. P. 444 M: AN SSSR, (1959); v.2. p.500 (1960); v.3. p.530 (1964); v.4. p.336. (1972); v.5. p.320. (1976.).

19 Programma i metodika biogeotsenologicheskikh issledovaniy. [Program and methodology for biogeocenological research.] P. 403 M.: Nauka. 1974.

20 Isachenko A.G. Metody polevykh landshaftnykh issledovaniy i landshaftno-ekologicheskoye kartografirovaniye. [Methods of field landscape research and landscape-ecological mapping.] p. 112 SPb., Publishing house of St. Petersburg State University,1998.

21 Transformatsiya rastitel'nogo pokrova Kazakhstana v usloviyakh sovremennogo prirodopol'sovaniya. [Transformation of the vegetation cover of Kazakhstan in the conditions of modern nature management.] Otchet o NIR; Rukovoditel’ N.P. Ogar’. – № GR0197RK0045. – Almaty, (1997.): 257.

22 Yurtsev B.A., Kamelin R.V. “Programmy floristicheskikh issledovaniy raznyh stenepii detal'nosti. [Teoreticheskiye i metodicheskiye problemy sranitel'noy floristiki.]” - L.: Nauka, (1987.):219-241.

23. Kurochkina, L.YA. “Monitoring i kartografirovaniye degradatsii rastitel'nykh formativ v ekosistemakh aridnogo Priaral'ya. [Monitoring and mapping of degradation of plant formations in ecosystems of the arid Aral Sea region.]” Arid ecosystems. v. 21.- №4 (65). (2015.). 5-21.

24 Flora Kazakhstana/ pod red. Pavlov N.V. [Flora of Kazakhstan.] vol. 1-9, Alma-Ata: Nauka, 1956-1966.

25 Illyustrirovanny opredelitel' rasteniy Kazakhstana. [Illustrated guide to plants of Kazakhstan.] Vol. 1. Alma-Ata: Nauka KazSSR, 1969., Vol.2. Alma-Ata: Nauka KazSSR, 1972.

26 Baytenov M.S. “Flora Kazakhstana [ Flora of Kazakhstan].”. vol.1. Almaty: Gylym, 1999.

27 Abdullina S.A “Spisok sosudistykh rasteniy Kazakhstana / Pod red. R.V. Kamelina. [List of vascular plants of Kazakhstan/ Ed. R.V. Kamelina].” p.187. Almaty,1999.

28 Oliva, G., dos Santos, E., Sofia, O., Umana, F., Massara, V., Martinez, G.G., Caruso, C., Cariac, G., Echevarria, D., Fantozzi, A. “The MARAS dataset, vegetation and soil characteristics of dryland rangelands across Patagonia.” Scientific Data Vol. 7, no1. (2020): DOI: 10.1038/s41597-020-00658-0

29 Ogar’ N.P. Rastitel'nost’ dolin rek // Botanicheskaya geografiya Kazakhstana i Sredney Azii (v predelakh pustynnoy oblasti) / Pod red. Ye.I. Rachkovskoy, Ye.A. Volkovoy, V.N. Khramtsova., [Vegetation of river valleys // Botanical geography of Kazakhstan and Central Asia (within the desert region) / Ed. E.I. Rachkovskaya, E.A. Volkova, V.N. Khramtsov.] p.138-141, St. Petersburg, 2003.

30 “Sozdanie pochvennyx i rastitel'nyx kart na territorii CHGNPP” za 2016 god [“Creation of a soil and plant map on the territory of the ChGNPP” for 2016] Razdel 1. Rukovoditel’ B.M.Sultanova, 2017.