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THE RATIO OF BOREAL AND STEPPE FLORISTIC ELEMENTS IN PHYTOCOENOSES INVOLVING *POPULUS ALBA*, *P NIGRA*, *P. TREMULA* AND *P.* × *CANESCENS* IN THE ZHAIYK RIVER FLOODPLAIN

Abstract: The article presents the results of a comprehensive ecological, phytocoenotic, and floristic study of forest communities involving representatives of the genus Populus L. in the Ural River valley within Western Kazakhstan. The research was conducted in 2024-2026 across steppe, semi-desert, and desert zones. Based on 26 geobotanical releves, a syntaxonomic analysis of floodplain and ravine forests was carried out, encompassing various elements of floodplain relief and moisture gradients. Four populations of the genus Populus were identified and characterized, represented by the species *Populus alba* L., *Populus nigra* L., *Populus canescens* (Aiton) Sm., and *Populus tremula* L. The studied phytocoenoses are characterized by pronounced vertical stratification, high floristic diversity, and a mosaic vegetation structure determined by differences in soil and hydrological conditions. The total number of vascular plant species within the communities ranges from 16-55. Species of the family Salicaceae plays a leading role in forming the coenotic core, while the herb layer is mainly represented by members of Poaceae, Asteraceae, and Fabaceae. Chorological analysis revealed the predominance of boreal forest and Eurasian floristic elements, with a significant contribution of steppe and Pontic species, reflecting the ecotonal nature of the region's floodplain forests. An expansion of the ecological-coenotic amplitude of certain species was observed under changing hydrological conditions, particularly within the desert zone.The obtained data supplement existing knowledge on the structure, floristic composition, and geographical distribution of poplar forests in Western Kazakhstan and are important for the monitoring and conservation of floodplain ecosystems.
Keywords: Populus, floodplain forests, phytocoenoses, floristic structure, boreal and steppe elements, Zhaiyk river.

Introduction

The genus *Populus* L. comprises deciduous forest-forming tree species belonging to the family *Salicaceae* (Mirbel). and plays an important role in the formation of floodplain and riparian forest ecosystems. In Western Kazakhstan, representatives of the genus *Populus* L. are mainly confined to the valley of the region's principal hydrological feature: the Zhaiyk river and are distributed along both its right and left banks over a stretch of approximately 700 km (Chibilev et al., 2023).

Within the study area, plantations of the genus *Populus* L. are represented by species belonging to two sections. Section Leuce Duby includes white and aspen-like poplars and is subdivided into two subsections. Subsection Albidae Dode comprises *Populus alba* L., occupying an area of 10,334.2 ha, and *Populus canescens* (Aiton) Sm., distributed over 8 ha. Subsection Trepidae Dode is represented by *Populus tremula* L., whose plantations cover 1,334 ha (Anatoliy et al., 2025).

Section Aigeiros Lunell, which includes black poplar forms, is represented by *Populus nigra* L., whose plantations occupy 16,667.7 ha (Klimov & Proshkin, 2024). This species is one of the principal forest-forming components of the Zhaiyk River floodplain ecosystems and plays a significant role in bank stabilization, regulation of the hydrological regime, and maintenance of biodiversity.

Within the floodplain, the channel, near-channel, central, and terrace-adjacent zones are distinguished, differing in relief morphology, hydrological regime, and vegetation cover. The indigenous (upland) banks are mainly represented by zonal steppe communities formed by feather-grass and Artemisia lerchiana formations (Figure 1).

The river floodplain is characterized by the development of azonal vegetation complexes, including floodplain forests and meadow communities. In the northern part of the valley, the average width of the floodplain is 12–13 km, locally increasing to 16 – 18 km, whereas southward it gradually narrows to 3–5 km (Khlyustov et al., 2019).

Morphologically, the floodplain has a flat-ridged relief formed by alternating ridges, interridge depressions, low-lying depressions, lakes, and oxbow channels.

The near-channel part of the floodplain, 200 – 400 m wide, is characterized by the predominance of arboreal phytocoenoses represented by white willow *Salix alba* and black poplar communities.

The central floodplain occupies the largest area, features a weakly expressed ridged relief, and ranges in width from 4 to 12 km. The terrace-adjacent floodplain forms a strip 1–2 km wide, locally narrowing to 400 – 500 m, and is predominantly overgrown with shrub vegetation.

The Trans-Ural – Turgai (West Kazakhstan) subprovince has not always been regarded as an independent unit and, in some literature sources, was included either within the Volga–Ural and Mugodzhar-Turgai subprovinces or within the Trans-Volga–West Kazakhstan subprovince (Petrenko et al., 1998).

The western boundary of the subprovince runs along the marginal part of the Southern Urals and the Ural River valley, corresponding to the boundary of the moderately continental climate, and extends eastward to the Turgai Plateau.

Figure 1

Forest phytocoenoses of the Zhaiyk river valley, June, 2025

The relief of the Trans – Ural -Turgai Province is predominantly flat. In its southern part, the marginal areas of the Mugodzhar Hills are located, with a maximum elevation of 657 m above sea level. In the eastern part, north of the Zhaiyk River, plains composed of alluvial and deluvial deposits prevail, with absolute elevations ranging from 450 to 300 m, whereas in the southern part the Pre-Ural Plateau is distinguished, with elevations from 450 to 100 m (Viktorov, 1951). In recent years, within the field of botanical geography, during the study of arid and subarid territories of the Palearctic and the vegetation cover of the Eurasian steppe zone, E.M. Lavrenko developed a botanical-geographical regionalization and established the latitudinal and longitudinal boundaries of steppe territories (Lavrenko, 1979).

The Pre-Ural Plateau is characterized by a diversity of parent materials: in addition to loamy deluvial deposits, chalk formations, Cretaceous sandy rocks, and saline clays are widespread. In combination with varied microrelief conditions, this determines the considerable diversity of vegetation cover.

I.N. Safronova subdivided the Pre-Ural Plateau into two subzonal types of dry sod-grass steppes formed on dark chestnut and chestnut soils (Safronova, 2002). The northern dry steppes on dark chestnut soils are characterized by the dominance of *Stipa lessingiana* and *Festuca valesiaca*, sometimes with a notable presence of *Stipa capillata*. The forb layer is mainly represented by xerophytic species such as *Tanacetum achilleifolium*, *Serratula dissecta*, and *Crinitaria tatarica* (Mirkin et al., 2015).

The aim of this article is to provide a detailed ecological-phytocoenotic and floristic characterization of the poplar forests of the Zhaiyk River, studied in its middle and lower reaches within the western region of Kazakhstan, as well as to identify their syntaxonomic diversity, structure, species composition, and geographical-ecological features under the conditions of steppe, semi-desert and desert natural zones.

Materials and methods

During the period from May 2024 to April 2026, a total of 26 geobotanical relevés were conducted in floodplain and ravine forests, and the resulting data were subsequently classified according to syntaxonomic principles. The size of the sampling plots was determined according to the homogeneity and structure of the community and measured 20 × 20 m. Species abundance was assessed using the Braun-Blanquet scale (Martynenko et al., 2008). In the synoptic table of syntaxa, species constancy is presented using an equal-interval scale with the following constancy classes: 1 – 1-20%; 2 – 21-40%; 3 – 41-60%; 4 – 61-80%; 5 – 81-100%. Species constancy within communities was evaluated using a five-point scale: I – 1-20%; II – 21-40%; III – 41-60%; IV – 61-80%; V – 81-100% (Ermakov & Martynenko, 2022).

The syntaxonomic analysis was performed in accordance with the generally accepted principles of ecological-floristic classification. The Latin names of plant species follow the checklist by M.M.Fartushinam (Chekalin & Fartushina, 2014) and were harmonized with the requirements of the International Code of Phytosociological Nomenclature (Theurillat et al., 2021).

Taxonomic identification of plants was carried out using fundamental floristic sources, including Flora of Kazakhstan (Pavlov, 1960), Key to Plants of Central Asia (Novikov, et al., 2018), as well as the generalizing works of V.V. Ivanov (Darbaeva et al., 2011). Species nomenclature is presented in accordance with current data from the international database Plants of the World Online (POWO) and the electronic resource Plantarium (http://www.ipni.org; https://powo.science.kew.org; https://www.plantarium.ru/).

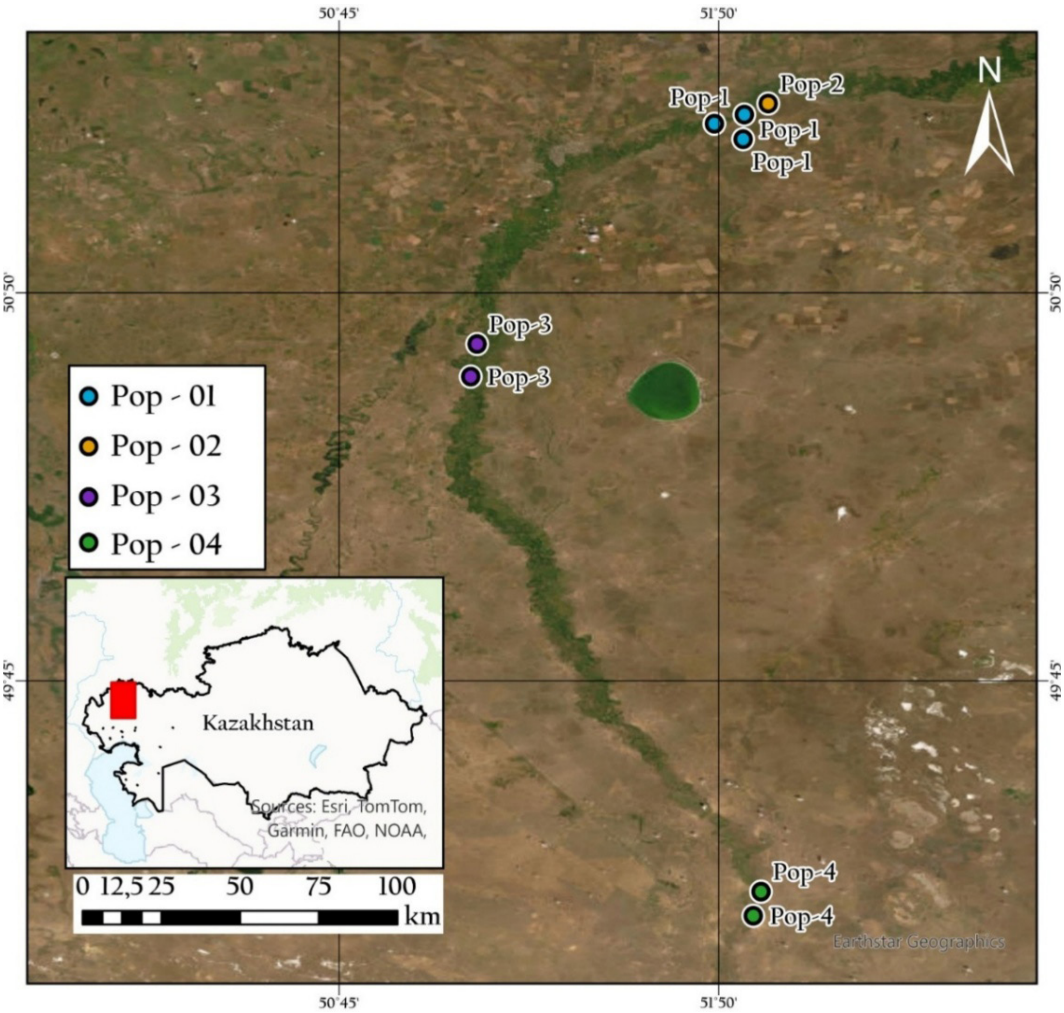
In the geographical regionalization of the vegetation cover of the study area, the monograph by E.M. Lavrenko "Steppes of Eurasia" (Lavrenko, 1991) served as the theoretical basis. To analyze the steppe zones and classify the plant communities of Western Kazakhstan, we integrated data from I.N. Safronova article (2002) and were guided by the general provisions of R.V. Kamelin (2012). The geographical regionalization of floodplain forests in the desert and semi-desert zones was carried out using data from the monograph Akzhigitova et al. (2003).

Field research was conducted across the West Kazakhstan Region within various natural zones. In the Terekty District, on the lands of the Chagan Forestry (village of Kabyltobe), floodplain forest communities of the first population were studied: twelve geobotanical relevés were carried out across extensive plots during the period from late April to late May (51°15.711′ N, 51°54.173′ E) at an absolute elevation of 5 m above sea level. The second population comprises four geobotanical relevés of ravine forests, completed in early May and mid-July (51°21.238′ N, 51°56.512′ E) at an elevation of 41 m above sea level.

In the semi-desert zone of the region, within the Baiterek District (village of Bogatskoye), the third population was investigated: five geobotanical releves were established during early spring and early autumn at sites with coordinates 50°40′20″ N, 51°08′24″ E and 51°05′73″ N, 51°14′41″ E, at absolute elevations of 45-46 m above sea level.

In the southern part of the region, within the desert zone, fieldwork was conducted on the territory of the Taipak Forestry, where the fourth population was studied: five geobotanical releves were carried out during the summer period, following the recession of floodwaters, at coordinates 49°09′64″ N, 51°32′50″ E and 49°09′422″ N, 51°33′185″ E, absolute relief elevations in this area reach – 6 m above sea level (Figure 2).

Figure 2
Map of the sampling locations of the described plant communities



Results and discussion

In Western Kazakhstan, within the Zhaiyk River valley, four populations of the genus Populus were identified. An ecological and phytocoenotic survey of plant communities involving species of the genus *Populus* was conducted, which made it possible to characterize their environmental conditions and community structure (Table 1).

The studied phytocoenoses are confined to floodplain and above-floodplain sites located within the steppe, semi-desert, and desert zones. Geobotanical relevés were carried out on 20 m² sample plots, in accordance with standard requirements for the study of tree – shrub and herbaceous communities. Absolute elevations range from – 6 to 46 m, reflecting both floodplain depressions and elevated terraces.

The soil cover is represented mainly by forest-meadow alluvial soils, dark chestnut meadow soils, and sandy soils, which determine the high mosaic structure of the vegetation cover and the diversity of ecological plant groups.

In all described communities, a clearly expressed vertical structure is observed:

Table 1
Differentiating groups of species formed with the participation of the genus Populus L.

Association	*Populus × canescens – Convallaria majalis*		*Populus alba – Carex vulpine*		*Populus nigra – Rubus caesius*		*Populus tremula -Aegopodium podagraria*		*Populus alba – Glycyrrhiza glabra*		*Populus nigra -Bromopsis inermis*		*Populus nigra – Melilotus albus*		*Populus nigra – Pseudosophora alopecuroides*		Species constancy
Zone	Steppe								Semi-desert				Desert				
Plot area, m²	20		20		20		20		20		20		20		20		
Mean tree height, m	18		20		21		12,5		21		22		18		19		
Total vegetation cover, %	75		70		65		55		60		65		50		40		
Absolute elevation, m	21		16		18		41		46		45		-6		-6		
Soil	Forest-meadow alluvial soil								Dark chestnut meadow soil				Sandy soil				
Number of species	25		19		16		30		29		25		20		18		
GPS	N51°15.711′ E51°54.173′		N51°19.741′ E51°54.199′		N51°20.461′ E51°55.528′		N51°21.238′ E51°56.512′		N50°40′.20′′ E 51°8.24′′		N 51°5.73′ E 51°14.41′		N 49°9.64′ E52°32.50′		N 49°9.422′ E 52°33.185′		
Releve number / layer designation	1.1		1.2		1.3		2.1		3.1		3.2		4.1		4.2		
Salicaceae																	
Populus alba L.	t1	2	t1	3	t1	2	t1	r	t1	4	t1	2	t1	2	·	·	III
Populus nigra L.	·	·	t1	+	t1	2	·	·	t1	2	t1	3	t1	3	t1	3	III
Populus × canescens (Aiton) Sm.	t1	5	·	·	·	·	·	·	·	·	·	·	·	·	·	·	I
Populus tremula L.	·	·	·	·	·	·	t1	5	·	·	·	·	·	·	·	·	I
Salix alba L.	t1	2	t1	1	t1	1	·	·	t1	2	·	·	t1	1	t1	1	III
Salix caspica Pall.	·	·	·	·	·	·	·	·	·	·	·	·	s1	r	·	·	I
Poaceae																	
Bromopsis riparia (Rehmann) Holub	·	·	·	·	·	·	·	·	h1	1	·	·	·	·	·	·	I
Bromopsis inermis (Leyss.) Holub	·	·	·	·	·	·	h1	+	·	·	h1	2	·	·	·	·	I
Setaria glauca (Poir.) Roem. & Schult.	·	·	·	·	·	·	·	·	h1	1		.	·	·	·	·	I
Poa pratensis L.	h1	1	.	.	·	·	h1	1	·	·	·	.	·	·	·	·	I
Calamagrostis epigeios (L.) Roth	·	·	h1	1	·	·	·	·	·	·	·	.	·	·		·	I

Continuation of the table

Calamagrostis neglecta (Ehrh.) Gaerth., Mey. et Scherb.	h1	1	·	·	·	·	·	·	·	·	·	.	·	·	·	·	I
Festuca valesiaca Gaudin	·	·	·	·	h1	1	·	·	·	·	·	.	·	·	·	·	I
Melica nutans L.	h1	1	·	·	·	·	·	·	·	·	·	·	·	·	·	·	I
Eremopyrum orientale L. Jaub. & Spach	·	·	·	·	·	·	·	·	·	·	·	·	h1	1	·	·	I
Melica altissima L.	·	·	·	·	·	·	h1	1	·	·	·	·	·	·	·	·	I
Cyperaceae																	
Carex vulpine L.	·	·	h1	2	·	·	·	·	·	·	·	·	·	·	·	·	I
Carex acuta L.	·	·	·	·	·	·	·	·	·	·	·	·	·	·	h1	1	I
Carex melanostachya M. Bieb. ex Willd.	·	·	·	·	·	·	h1	1	·	·	·	·	h1	1	·	·	I
Carex leporina L.	·	·	·	·	·	·	h1	1	·	·	·	·	·	·	·	·	I
Alliaceae																	
Allium lineare L.	·	·	·	·	·	·	·	·	h1	r	·	·	h1	r	·	·	II
Liliaceae																	
Fritillaria meleagris L.	h1	r	·	·	·	·	·	·	·	·	·	·	·	·	·	·	I
Iridaceae																	
Iris pseudacorus L.	·	·	h1	1	·	·	·	·	h1	1	·	·	·	·	·	·	II
Juncaceae																	
Juncus compressus Jacq.	·	·	·	·	·	·	·	·	h1	1	·	·	·	·	·	·	I
Asparagaceae																	
Asparagus officinalis L.	·	·	·	·	·	·	·	·	h1	1	·	·	·	·	·	·	I
Amaranthaceae																	
Amaranthus albus L.	·	·	·	·	·	·	·	·	h1	+	h1	1	·	·	·	·	I
Convallariaceae																	
Convallaria majalis L.	h1	3	·	·	·	·	h1	+	·	·	·	·	·	·	·	·	I
Aceraceae																	
Acer negundo L.	t1	1	t1	1	t1	1	t1	+	·	·	·	·	t1	+	·	·	II
Fagaceae																	
Quercus robur L.	t1	r	·	·	·	·	·	·	·	·	·	·	·	·	·	·	I

Continuation of the table

Oleaceae																	
Fraxinus americana L.	·	·	·	·	·	·	t1	r	·	·	·	·	·	·	·	·	I
Betulaceae																	
Betula pendula Roth	·	·	·	·	·	·	t1	r	·	·	·	·	·	·	·	·	I
Aristolochiaceae																	
Aristolochia clematitis L.	ss1	+	·	·	ss1	1	·	·	·	·	·	·	·	·	·	·	I
Rosacaeae																	
Prunus spinosa L.	·	·	s1	1	·	·	·	·	s1	1	·	·	·	·	·	·	II
Rubus caesius L.	·	·	·	·	ss1	2	·	·	·	·	·	·	·	·	ss1	2	II
Cerasus fruticosa Pall.							s1	r	·	·	·	·	·	·	·	·	I
Spiraea hypericifolia L.	·	·	·	·	·	·	s1	1	·	·	·	·	·	·	·	·	I
Amygdalus nana L.	·	·	·	·	·	·	s1	2	·	·	·	·	·	·	·	·	I
Rosa canina L.	·	·	·	·	·	·	s1	+	·	·	·	·	·	·	·	·	I
Crataegus ambigua C.A. Mey. ex A.K. Becker	·	·	·	·	·	·	s1	1	·	·	·	·	·	·	·	·	I
Celastraceae																	
Euonymus verrucosus Scop.	s1	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	I
Brassicaceae																	
Chorispora tenella (Pall.) DC.	·	·	h1	1	h1	1	·	·	·	·	·	·	·	·	·	·	I
Sisymbrium altissimum L.	·	·	h1	+	·	·	·	·	·	·	·	·	·	·	·	·	I
Ranunculaceae																	
Thalictrum flavum L.	·	·	·	·	h1	1	·	·	·	·	·	·	·	·	·	·	I
Thalictrum minus L.	·	·	h1	1	·	·	·	·	·	·	·	·	·	·	·	·	I
Lamiaceae																	
Phlomoides tuberosa (L.) Moench	·	·	·	·	·	·	·	·	h1	+	·	·	·	·	·	·	I
Mentha aquatica L.	·	·	·	·	·	·	·	·	h1	+	·	·	·	·	·	·	I
Salvia pratensis L.	·	·	·	·	·	·	·	·	h1	1	·	·	·	·	·	·	I
Glechoma hederacea L.	·	·	·	·	·	·	·	·	h1	+	·	·	·	·	·	·	I
Leonurus cardiaca L.	·	·	·	·	·	·	h1	r	.	.	h1	r	h1	1	·	·	II
Lycopus europaeus L.	·	·	·	·	·	·	·	·	.	.	h1	+	·	·	·	·	I
Stachys palustris L.	.	.	·	·	·	·	·	·	·	·	·	·	h1	1	·	·	I

Continuation of the table

Lamium amplexicaule L.	h1	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	I
Lythraceae																	
Lythrum salicaria L.	h1	2	·	·	·	·	·	·	·	·	·	·	·	·	·	·	I
Rubiaceae																	
Galium boreale L.	h1	2	·	·	·	·	h1	1	·	·	·	·	·	·	·	·	I
Fabaceae																	
Glycyrrhiza glabra L.	·	·	·	·	·	·	·	·	h1	3	.	.	h1	1	·	·	II
Glycyrrhiza aspera Pall.	·	·	·	·	·	·	·	·	·	·	·	·	h1	2	·	·	I
Lathyrus tuberosus L.	h1	1	·	·	·	·	·	·	h1	2	·	·	·	·	·	·	II
Medicago falcata L.	·	·	h1	2	·	·	·	·	·	·	·	·	·	·	h1	1	II
Melilotus albus Medik.	·	·	·	·	h1	2	·	·	·	·	·	·	h1	3	.	.	II
Trifolium arvense L.	h1	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	I
Trifolium repens L.	·	·	·	·	·	·	h1	+	·	·	·	·	·	·	·	·	I
Lotus corniculatus L.	·	·	·	·	·	·	·	·	·	·	·	·	h1	+	.	.	I
Alhagi pseudalhagi (M. Bieb.) Desv. ex Wangerin	·	·	·	·	·	·	·	·	·	·	·	·	·	·	h1	3	I
Pseudosophora alopecuroi-des (L.) Sweet	·	·	·	·	·	·	·	·	·	·	·	·	·	·	h1	2	I
Cytisus borysthenicus (Gruner) Klásk.	·	·	·	·	·	·	s1	+	·	·	·	·	·	·	·	·	I
Polygonaceae																	
Rumex confertus Willd.	·	·	·	·	·	·	·	·	h1	+	·	·	h1	1	·	·	II
Polygonum aviculare L.	·	·	·	·	·	·	·	·	h1	1	·	·	h1	1	·	·	II
Persicaria amphibia (L.) Delarbre	·	·	·	·	·	·	·	·	·	·	h1	+	·	·	·	·	I
Solanaceae																	
Solanum dulcamara L.	·	·	·	·	·	·	·	·	h1	r	·	·	h1	+	·	·	II
Tamaricaceae																	
Tamarix ramosissima Ledeb.	·	·	·	·	·	·	·	·	·	·	·	·	·	·	h1	2	I
Chenopodiaceae																	
Atriplex cana C.A. Mey.	·	·	·	·	·	·	·	·	ss1	1	·	·	ss1	1	·	·	I
Atriplex micrantha Ledeb.	·	·	·	·	·	·	·	·	·	·	h1	1	·	·	·	·	I
Bassia prostrata (L.) Beck	·	·	·	·	·	·	·	·	·	·	·	·	·	·	h1	+	I

Continuation of the table

Plantaginaceae																	
Plantago maxima Juss. ex Jacq.	.	.	.	.	.	.	.	.	h1	1	.	.	.	.	.	.	I
Plantago lanceolata L.	.	.	.	.	.	.	.	.	.	.	h1	+	.	.	.	.	I
Plantago major L.	h1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Scrophulariaceae																	
Gratiola officinalis L.	.	.	.	.	.	.	.	.	h1	r	.	.	.	.	.	.	I
Veronica longifolia L.	.	.	.	.	.	.	.	.	h1	+	.	.	.	.	.	.	I
Linaria vulgaris Mill.	.	.	.	.	.	.	.	.	.	.	.	.	h1	1	.	.	I
Dodartia orientalis L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	h1	1	I
Scrophularia nodosa L.	h1	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Plumbaginaceae																	
Limonium gmelinii (Willd.) Kuntze	.	.	.	.	.	.	.	.	h1	1	.	.	.	.	.	.	I
Euphorbiaceae																	
Euphorbia palustris L.	.	.	.	.	.	.	.	.	h1	1	.	.	.	.	.	.	I
Euphorbia seguieriana Neck.	.	.	.	.	h1	1	.	.	.	.	.	.	.	.	.	.	I
Butomaceae																	
Butomus umbellatus L.	.	.	.	.	.	.	.	.	h1	+	.	.	.	.	.	.	I
Ulmaceae																	
Ulmus laevis Pall.	t1	2	t1	1	t1	2	.	.	t1	+	.	.	.	.	.	.	II
Rhamnaceae																	
Rhamnus cathartica L.	.	.	.	.	.	.	.	.	s1	+	.	.	.	.	.	.	I
Frangula alnus Mill.	s1	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Caprifoliaceae																	
Lonicera tatarica L.	.	.	.	.	.	.	s1	1	.	.	.	.	.	.	.	.	I
Crassulaceae																	
Hylotelephium triphyllum (Haw.) Holub	.	.	.	.	.	.	.	.	.	.	h1	+	.	.	.	.	I
Apiaceae																	
Eryngium planum L.	h1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Silaum silaus (L.) Schinz & Thell.	.	.	.	.	.	.	.	.	.	.	h1	.	.	.	.	.	I

Continuation of the table

Sium latifolium L.	·	·	·	·	·	·	h1	+	·	·	·	·	·	·		·	I
Aegopodium podagraria L.	·	·	·	·	·	·	h1	1	·	·	·	·	·	·	·	·	I
							Malvaceae										
Malva thuringiaca (L.) Vis.	·	·	·	·	·	·	·	·	·	·	h1	·	·	·	·	·	I
							Cannabaceae										
Cannabis sativa L.	·	·	·	·	·	·	·	·	·	·	·	·	·	·	h1	2	I
							Urticaceae										
Urtica dioica L.	·	·	·	·	·	·	h1	+	·	·	·	·	·	·	·	·	I
							Elaeagnaceae										
Elaeagnus commutata Bernh. ex Rydb.	·	·	·	·	·	·	·	·	·	·	·	·	s1	+	·	·	I
Oberna behen (L.) Ikonn.	h1	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	I
Silene nutans L.	.	.	h1	+	·	·	·	·	·	·	·	·	·	·	·	·	I
Herniaria glabra L.	·	·	·	·	·	·	·	·	·	·	·	·	·	·	h1	+	I
							Convolvulaceae										
Convolvulus arvensis L.	·	·	h1	+	·	·	·	·	·	·	h1	1	.	.	h1	1	III
							Campanulaceae										
Campanula sibirica L.	h1	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	I
Campanula ruthenica M. Bieb.	·	·	·	·	·	·	h1	+	·	·	·	·	·	·	·	·	I
							Violaceae										
Viola canina L.	.	.	h1	+	·	·	·	·	·	·	·	·	·	·	·	·	I
Viola elatior Fries.	·	·	·	·	h1	+	·	·	·	·	·	·	·	·	·	·	I
							Asteraceae										
Inula salicina L.	·	·	·	·	·	·	·	·	·	·	h1	1	·	·	h1	+	II
Arctium lappa L.	·	·	·	·	·	·	h1	+	·	·	·	·	·	·	·	·	
Inula britannica L.	.	.	h1	1	·	·	·	·	·	·	h1	1	·	·	h1	1	II
Inula germanica L.	·	·	·	·	h1	1	·	·	·	·	·	·	·	·	·	·	I
Inula helenium L.	·	·	·	·	·	·	h1	1	·	·	·	·	·	·	·	·	I
Xanthium spinosum L.	·	·	·	·	·	·	·	·	·	·	h1	1	h1	·	·	·	II
Senecio erucifolius L.	·	·	·	·	·	·	·	·	·	·	h1	1	.	·	·	·	I
Artemisia marschalliana Spreng.	·	·	·	·	·	·	·	·	ss1	1	·	·	.	·	·	·	I

Continuation of the table

Artemisia prasina Krasch. ex Poljak.	.	.	.	.	.	.	.	.	.	.	ss1	1	.	.	.	.	I
Artemisia absinthium L.	h1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Artemisia vulgaris L.	.	.	h1	+	.	.	.	.	.	.	.	.	.	.	.	.	I
Artemisia lercheana Weber ex Stechm.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	h1	2	I
Sonchus arvensis L.	.	.	.	.	.	.	.	.	.	.	h1	1	.	.	.	.	I
Cichorium intybus C. Presl Arcang.	.	.	.	.	.	.	.	.	.	.	h1	1	.	.	h1	1	II
Lactuca tatarica (L.) C.A. Mey.	.	.	.	.	.	.	.	.	.	.	h1	+	.	.	.	.	I
Tripleurospermum inodorum (L.) Sch. Bip.	.	.	.	.	.	.	.	.	.	.	h1	2	.	.	h1	1	II
Arctium lappa L.	.	.	.	.	.	.	.	.	.	.	h1	1	.	.	.	.	I
Pulicaria vulgaris Gaertn.	.	.	.	.	.	.	.	.	.	.	h1	+	.	.	.	.	I
Taraxacum officinale F.H. Wigg.	.	.	.	.	.	.	.	.	.	.	h1	1	.	.	.	.	I
Achillea millefolium L.	.	.	h1	+	.	.	.	.	.	.	.	.	.	.	.	.	I
Conyza canadensis (L.) Cronquist	.	.	.	.	h1	1	.	.	.	.	.	.	.	.	.	.	I
Lactuca tatarica (L.) C.A. Mey.	.	.	.	.	h1	+	.	.	.	.	.	.	.	.	.	.	I
Lactuca serriola L.	.	.	.	.	.	.	h1	r	.	.	.	.	.	.	.	.	I
Centaurea scabiosa L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	h1	1	I
Hieracium echioides (Lumn.) F.W. Schultz & Sch. Bip.	.	.	.	.	.	.	h1	r	.	.	.	.	.	.	.	.	I

Note: t1 – first tree layer (upper tree canopy), s1 – shrub layer,ss1 – subshrub layer, h1 – herbaceous layer.Constancy classes (%):I – 1-20 %, II – 21-40 %, III – 41–60 %, IV – 61–80 %,V – 81–100 %. Species abundance according to the Braun-Blanquet scale: r – solitary individuals, negligible cover – few individuals, cover < 1 % 1 – numerous individuals, but cover 1–5 %, 2 – 6-25 % , 3 – 26–50 %, 4 – 51–75 %, 5 – 76–100 %

Tree layer (t1). Dominated by species of the family Salicaceae, primarily *Populus alba*, *Populus nigra*, and *Populus canescens*; less frequently *Populus tremula* and *Salix alba*. The average height of the tree stand ranges from 12.5 to 22 m, indicating mature and middle-aged plantations.

Shrub and subshrub layers (s1, ss1). Developed unevenly. The most common species include Rubus caesius, *Prunus spinosa*, *Euonymus verrucosus*, as well as halophytic and xerophytic subshrubs such as *Artemisia marschalliana* and *Atriplex cana*.

Herb layer (h1). Characterized by high floristic diversity and plays a key role in forming the total projective cover. Total projective cover varies from 40 to 75%, reflecting differences in community closure, moisture, and light conditions.

The number of species in the communities ranges from 16 to 30, which is typical for floodplain and transitional ecosystems. The highest species richness was recorded in communities involving *Populus tremula* and *Aegopodium podagraria*, where favorable mesophytic conditions are formed.

In the herb layer, representatives of the following families dominate: Poaceae: *Bromopsis inermis, Calamagrostis epigeios, Poa pratensis; Asteraceae: Inula britannica, Artemisia vulgaris, Achillea millefolium*; Fabaceae: *Glycyrrhiza glabra, Melilotus albus, Medicago falcata;* Cyperaceae*: Carex vulpina, Carex acuta.*

The presence of Fabaceae species indicates increased soil trophicity and their capacity for biological nitrogen fixation.

Ecological and phytocoenotic interpretation based on the constancy scale shows that most species belong to class I (1–33%), reflecting the high dynamism and mosaic structure of the vegetation cover (Golovanov et al., 2025). Species of constancy class III (*Populus alba*, *Populus nigra*, *Salix alba*) form the coenotic core of the communities and determine their physiognomic appearance.

The first population was identified in the Terekti District, within the Chagan Forestry, compartment №4 (GPS: N 51°19.758′, E 051°54.208′), at an elevation of 5 m above sea level. Geographically, this population is confined to a ravine-gully system originating from the Pre-Ural Plateau and transitioning into the central floodplain. The microclimatic conditions of forests with *Populus canescens* create favorable conditions for its growth on alluvial-meadow soils (GBIF Backbone Taxonomy, 2026).

The plant community of the first population is represented by a mixed tree – shrub – herb phytocoenosis. The most widespread formations are: *Populus canescens – Convallaria majalis*, *Populus alba – Carex vulpina*, *Populus nigra – Rubus caesius*.

The tree layer is formed by *Populus canescens, Populus tremula, Fraxinus Americana* and *Ulmus laevis.*

The understory (second layer) includes shrub species such as *Rhamnus cathartica*, *Rosa cinnamomea* and *Prunus spinosa*.

The third layer is formed by the subshrub *Rubus caesius*.

The herbaceous cover (fourth layer) is distinguished by high species diversity and includes *Festuca ovina, Lathyrus tuberosus, Convallaria majalis, Aristolochia clematitis, Carex vulpina, Artemisia vulgaris, Chelidonium majus, Veronica longifolia, Medicago falcata*, *Trifolium montanum, Cichorium intybus, Euphorbia seguieriana, Bromus inermis, Conyza canadensis, Elytrigia repens* and other species.

The phytocoenosis is characterized by pronounced vertical stratification and high heterogeneity of the herb layer, which is typical of floodplain forest ecosystems with well-developed microrelief and optimal moisture conditions.

The floristic composition of the herb layer shows considerable taxonomic diversity. The largest number of species belongs to the family Asteraceae – 8 species 14.5%. The second position in terms of species richness is occupied by Fabaceae – 5 species 11.9%. The third place belongs to Poaceae, represented by 4 species 7.2%.

Several families are represented by single species, including Aristolochiaceae, Cyperaceae, Papaveraceae, Convallariaceae, Euphorbiaceae, Polygonaceae, Ranunculaceae, and Scrophulariaceae.

Overall, within the central floodplain, the first population includes 55 species of vascular plants belonging to 20 families and 41 genera, indicating high floristic richness of the studied phytocoenosis.

In the flora of the investigated community, 11 geographical elements were identified (Table 2).

Figure 3
Association of the central floodplain
Populus × canescens – Convallaria majalis, April, 2025

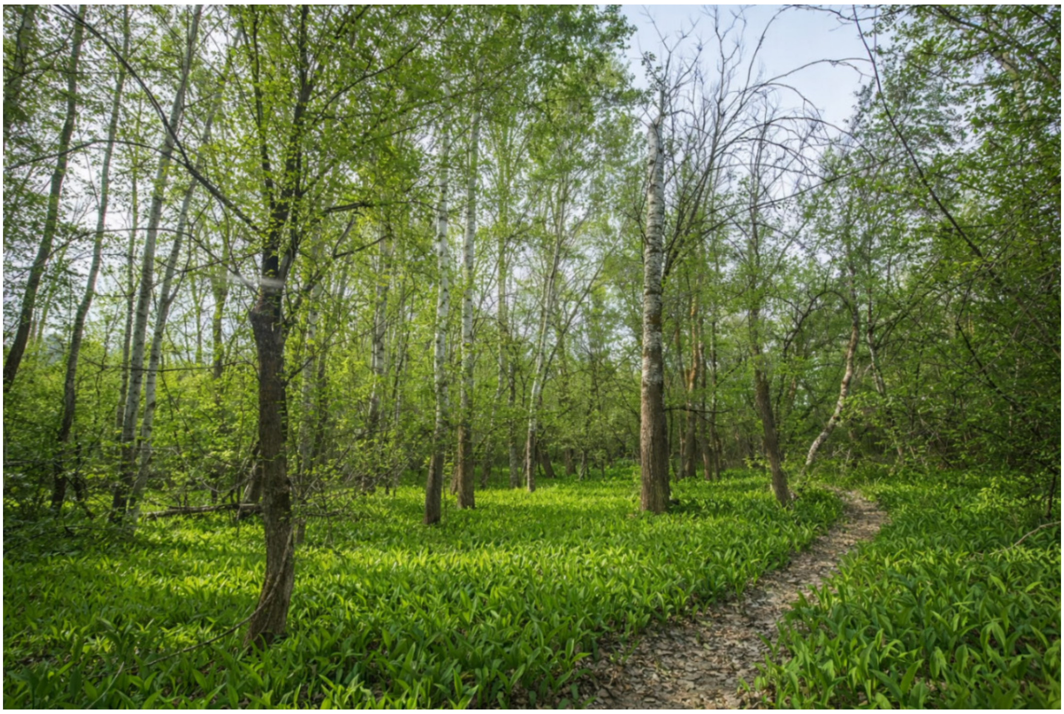


Table 2
Distribution of plant species by geographical ranges for the first population

Range group	Floral elements	Number of species	% of the total number
Boreal forest		40	72.7
	Eurasian	11	20.3
	Euro-Siberian	8	14.8
	European	9	16.6
	Holarctic	5	9
	East European	1	1.8
Steppe		11	20.3
	Pontic	3	5.5
	Ancient Mediterranean	3	5.5
	Mediterranean	4	7.2
	Pontic–Trans-Volga–Kazakhstan	1	1.8
Adventive ruderal (Pluriregional)		4	7.4
	North American	4	7.4
Total		**55**	**100**

Among the geographical elements of the first population, Eurasian species predominate (11 species; 20.3%), including *Prunus spinosa*, *Rhamnus cathartica*, *Rosa cinnamomea*, and *Bromopsis inermis*. The Euro-Siberian element comprises 8 species (14.8%); *Rubus caesius*, *Chelidonium majus*, *Festuca valesiaca*. The Holarctic element (5 species; 9%) includes *Bidens tripartita*, *Artemisia vulgaris*, and *Cichorium intybus*. These groups belong to the Boreal chorological group.

The Mediterranean element (4 species; 7.2%) includes *Populus alba* and *Convallaria majalis*, while the Ancient Mediterranean element (3 species; 5.5%) is represented by *Medicago falcata* and *Lactuca tatarica*. The Pontic element (3 species; 5.5%) includes *Euphorbia seguieriana* and *Polygonum aviculare*. Steppe species account for 11 species (20.3%) and are well developed along forest edges.

Weedy or adventive species are few (4 species; 7.4%), including *Fraxinus americana*, *Conyza canadensis*, and *Acer negundo*.

In the second population, the studied phytocoenosis is represented by a ravine deciduous forest of the forest-steppe zone, confined to the bottoms and slopes of gullies. The community develops under conditions of increased moisture and a moderated microclimate typical of depressed relief forms. The vegetation cover belongs to the association *Populus tremula – Aegopodium podagraria* and is located at 51°21.238′ N, 51°56.512′ E, at an absolute elevation of 41 m above sea level.

Within this phytocoenosis, 30 species of vascular plants were recorded, belonging to the division *Magnoliophyta* (angiosperms), represented by two classes – *Magnoliopsida* (dicotyledons) and *Liliopsida* (monocotyledons). Dicotyledonous plants predominate, which is typical of ravine forest communities of the forest-steppe zone.

The flora of the phytocoenosis includes 14 families and 27 genera, indicating relatively high taxonomic diversity and stability of the vegetation cover under dissected relief and increased moisture conditions.

The most represented families are: Rosaceae – 6 species (20%): *Cerasus fruticosa*, *Spiraea hypericifolia*, *Amygdalus nana*, *Rosa canina*, *Crataegus ambigua*, *Fragaria vesca*, Asteraceae – 4 species (13.3%): *Inula helenium*, *Hieracium echioides*, *Lactuca serriola*, *Arctium lappa*, Poaceae – 3 species (10%): *Bromopsis inermis*, *Poa pratensis*, *Melica altissima*, Apiaceae – 2 species (6.6%): *Sium latifolium*, *Aegopodium podagraria*; Salicaceae – 2 species (6.6%): *Populus tremula*, *Populus alba*.

The tree layer is composed of deciduous species, with an average tree height of about 12,5 m. The dominant species is *Populus tremula*, forming the basis of the association. The layer also includes *Populus alba*, *Fraxinus americana*, *Acer negundo*, and *Betula pendula*. The canopy closure is moderate, allowing sufficient light penetration to the lower layers.

The shrub layer is well developed but heterogeneous. It is mainly represented by species of the family Rosaceae and steppe elements: *Cerasus fruticosa*, *Spiraea hypericifolia*, *Amygdalus nana*, *Rosa canina*, *Crataegus ambigua*, as well as *Lonicera tatarica*. Shrubs form a sparse understory, especially pronounced on gully slopes and forest edges.

The herbaceous layer is the richest in species composition and exhibits a mosaic structure. The dominant species is *Aegopodium podagraria*, forming a dense ground cover. Grasses and sedges (*Bromopsis inermis*, *Poa pratensis*, *Carex melanostachya*) are widely represented, along with forest, meadow and edge forbs (*Convallaria majalis*, *Galium boreale*, *Inula helenium*, *Fragaria vesca*). The presence of ruderal and adventive species indicates moderate anthropogenic impact.

A total of 30 species of vascular plants belonging to various floristic–geographical elements were identified within the phytocoenosis.

Analysis of the distribution of species by range groups makes it possible to assess the origin of the flora and the ecological specificity of the community (Table 3).

Figure 4
Ravine forest phytocoenoses of Populus tremula, June, 2025

Table 3

Distribution of plants by geographical ranges in the second population

Range group	Floral elements	Number of species	% of the total number
Boreal forest		20	66.6
	Eurasian	8	26.6
	Euro-Siberian	5	16.6
	European	2	6.6
	Holarctic	5	16.6
Steppe		8	26.6
	Pontic	5	16.6
	Mediterranean	2	6.6
	Lower Volga	1	3.3
Adventive ruderal (Pluriregional)		2	6.6
	North American	1	3.3
	Canada	1	3.3
Total		**30**	**100**

The boreal forest geo-element is the most widely represented, comprising 20 species (66.6% of the total flora). Within this group, the following are distinguished: Eurasian elements 8 species (26.6%): *Populus tremula*, *Bromopsis inermis*, *Carex melanostachya*, *Melica altissima*, *Rosa canina*, *Galium boreale*, Euro-Siberian elements 5 species (16.6%): *Sium latifolium*, *Inula helenium*, *Betula pendula*, *Aegopodium podagraria*, Holarctic elements 5 species (16.6%): *Poa pratensis*, *Arctium lappa*, *Fragaria vesca*, European elements 2 species (6.6%): *Convallaria majalis*, *Leonurus cardiaca*.

The high proportion of boreal species indicates the forest character of the phytocoenosis and its connection with moderately moist growing conditions typical of ravine forests.The steppe geo-element is represented by 8 species (26.6% of the flora), including:Pontic species 5 (16.6%): *Cerasus fruticosa*, *Spiraea hypericifolia*, *Amygdalus nana*, *Hieracium echioides*, *Cytisus borysthenicus*, Mediterranean species; 2 (6.6%): *Lactuca serriola*, *Populus alba*;Lower Volga element; 1 (3.3%): *Crataegus ambigua*.The significant share of steppe and Pontic species reflects the ecotonal character of ravine forests formed within the forest-steppe zone and influenced by adjacent steppe communities.The adventive (pluriregional) ruderal group includes 2 species (6.6%) North American element – *Acer negundo* (3.3%), Canadian element – *Fraxinus americana* (3.3%).

The presence of adventive species indicates anthropogenic influence and a certain degree of transformation of the natural vegetation cover.

Thus, the chorological analysis shows that the flora of the *Populus tremula – Aegopodium podagraria* phytocoenosis is characterized by dominance of boreal forest geo-elements significant participation of steppe and Pontic species, presence of adventive elements.

This confirms the forest-steppe, ecotonal nature of the ravine forest formed at the junction of forest and steppe floristic complexes, under moderate anthropogenic influence.

The first and second populations are confined to the North Caspian region, within the physical-geographical province of the Koshim-Zhaiyk steppe district of the Caspian – Turanian country. This territory covers the steppe zone of the upper course of the Zhaiyk River.

The boreal forest geo-element is the most widely represented and includes 20 species, accounting for 66.6% of the total number of species. Within this group the following elements predominate: Eurasian elements – 8 species (26.6%): *Populus tremula*, *Bromopsis inermis*, *Carex melanostachya*, *Melica altissima*, *Rosa canina*, *Galium boreale*. Euro-Siberian elements 5 species (16.6%) – *Sium latifolium*, *Inula helenium*, *Betula pendula*, *Aegopodium podagraria*, *Sium latifolium*. Holarctic elements 5 species (16.6%): *Poa pratensis*, *Arctium lappa*, *Fragaria vesca*. European elements 2 species (6.6%): *Convallaria majalis*, *Leonurus cardiaca*.

The high proportion of boreal species indicates the forest character of the phytocoenosis and its association with moderately humid growing conditions typical of ravine forests.

The steppe geo-element is represented by 8 species, which corresponds to 26.6% of the flora. The following elements are distinguished within it: Pontic species 5 (16.6%) – *Cerasus fruticosa*, *Spiraea hypericifolia*, *Amygdalus nana*, *Hieracium echioides*, *Cytisus borysthenicus*. Mediterranean species – 2 (6.6%): *Lactuca serriola*, *Populus alba*. Lower Volga element – 1 (3.3%): *Crataegus ambigua*.

The third population was identified at the boundary of the semi-desert zone, near the village of Bogatsk (GPS: N 50°39.282′, E 051°08.578′), in compartment No. 49 of the Ural Forestry. At an elevation of 46 m above sea level, forest formations involving *Populus alba* and *Populus nigra* were studied under conditions of the central floodplain.

The third population is located in the Zhayik River valley and belongs to the semi-desert arid zone extending for approximately 200 km. Annual precipitation is relatively low (210 – 260 mm), with most of it falling during the warm season and largely evaporating. In winter, snow cover does not exceed 20 – 30 cm, strong winds redistribute snow, causing its accumulation in depressions. This results in insufficient spring soil moisture, leading to changes in vegetation cover.

Within the third population, the dominant community types are: *Populus alba – Aristolochia clematitis*, *Populus nigra – Glycyrrhiza glabra*.

The tree layer of the floodplain forest is formed by *Populus alba*, *Populus nigra*, *Salix alba*, *Acer negundo* and *Ulmus pumila*.

The shrub layer is represented by *Rhamnus cathartica*, *Elaeagnus commutata* and *Rosa cinnamomea*.

Over the past two years, spring flooding in the central floodplain lasting 45–50 days has promoted the active development of the herbaceous layer, which spreads intensively across the surface soil horizons. The most widespread species is *Glycyrrhiza glabra*, whose annual shoot length has doubled under these conditions.

Within the studied area of the central floodplain, the flora is represented by three range groups and comprises 10 geographical elements (Table 4).

Figure 5
Association of the semi-desert zone Populus alba – Glycyrrhiza glabra, June, 2025

Table 4
Distribution of plant species by geographical ranges for the third population

Range group	Floral elements	Number of species	% of the total number
Boreal forest		40	74
	Eurasian	14	25.9
	Euro-Siberian	5	9.2
	European	9	16.6
	Holarctic	12	22.2
	Boreal	1	1.8

Continuation of the table

Range group	Floral elements	Number of species	% of the total number
Steppe		11	21.8
	Pontic	4	7.4
	Ancient Mediterranean	5	9.2
	Mediterranean	2	3.6
Adventive ruderal (Pluriregional)		3	5.5
	American	1	1.8
	Pluriregional	2	3.6
Total		**54**	**100**

For the third population, the flora is distributed among the following geographical elements:

Boreal forest group Eurasian element (14 species; 25.9%): *Rhamnus cathartica*, *Inula salicina*, *Hylotelephium triphyllum*, *Thalictrum flavum*, *Bromopsis inermis*, *Eryngium planum*. Holarctic element (12 species; 22.2%): *Artemisia marschalliana*, *Artemisia prasina*, *Sonchus arvensis*, *Cichorium intybus*, *Polygonum aviculare*, *Persicaria amphibia*, *Silene vulgaris*. European element (9 species; 16.6%): *Ulmus laevis*, *Asparagus officinalis*, *Mentha aquatica*, *Tripleurospermum inodorum*, *Solanum dulcamara*, *Leonurus cardiaca*, *Salix alba*, *Iris pseudacorus*. Euro-Siberian element (5 species; 9.2%): *Gratiola officinalis*, *Euphorbia palustris*, *Senecio erucifolius*, *Rumex confertus*, *Veronica longifolia*.

Steppe group Ancient Mediterranean element (5 species; 9.2%): *Lactuca tatarica*, *Atriplex cana*, *Atriplex micrantha*, *Allium lineare*, *Glycyrrhiza glabra*.Pontic element (4 species; 7.4%): *Phlomoides tuberosa*, *Salvia pratensis*, *Limonium gmelinii*.Mediterranean element (2 species; 3.6%): *Plantago lanceolata*, *Populus alba*.

Adventive (ruderal) group Pluriregional elements: *Setaria glauca*, *Convolvulus arvensis*.American element (1 species; 1.8%): *Xanthium spinosum*.

The flora of the third population is diverse and includes 38 species belonging to 16 families and 25 genera. The dominant families are:Asteraceae – 13 species 26.5%; Fabaceae – 9 species 18.3%; Polygonaceae – 6 species 12.2%; Cyperaceae and Poaceae – 5 species each 10.2%; Salicaceae – 3 species 6.1%. Other families (*Scrophulariaceae*, *Lythraceae*, *Rhamnaceae*, *Elaeagnaceae*, *Solanaceae*) are represented by single species about 2% each.

The fourth population is located within a forest massif in the desert zone near the village of Taipak, at the extreme boundary of the middle course of the Ural River. The site is situated in compartment №10 (GPS: N 49°05.714′, E 051°56.493′), where *Populus nigra* and *Populus alba* occur. The absolute elevation of the territory is 6 m relative to sea level. Despite its proximity to the central floodplain, soils are predominantly clayey and loose sandy.

This population belongs to the desert zone. The main forest-forming phytocoenotic groups are represented by *Populus nigra – Melilotus albus* communities, and locally by small patches of *Populus alba – Rubus caesius*.

During the study, particular attention was drawn to the fact that following strong floods in recent years within the desert zone, in the central floodplain *Rubus caesius* began to grow together with representatives of the genus *Populus*. This indicates a noticeable expansion of the species' range and a possible shift in its ecological-coenotic preferences.

Such co-occurrence may also suggest restructuring of plant communities in floodplain areas of the desert zone, likely associated with changes in the hydrological regime and increased habitat moisture following flooding events.

The analysis of life forms revealed that perennial polycarpic plants predominate in the population – 34 species 89.4%. Perennial forest species are characterized by a long growing season and the ability to renew shoots annually.

Annual monocarpic plants account for 4 species 10.5% and include *Thlaspi arvense*, *Capsella bursa-pastoris, Silene dichotoma, Conyza canadensis,* and *Bidens tripartita* which grow in floodplain forests mainly during spring and summer.

In maintaining the stability of forest plant communities, the dominant role among herbaceous species is played by representatives of the following families: Poaceae – 4 species 10.2% – *Bromus inermis*, *Elytrigia repens*, *Festuca rubra*, *Calamagrostis epigeios*, Fabaceae – 4 species 10.2% – *Melilotus albus*, *Vicia cracca*, *Lathyrus pisiformis*, *Alhagi pseudalhagi*, Asteraceae – 8 species 20.5%: *Taraxacum officinale*, *Lactuca tatarica*, *Conyza canadensis*, *Bidens tripartita*, *Cichorium intybus*, *Artemisia vulgaris*, *Inula germanica*.

Representatives of Polygonaceae – 2 species 5.1% – *Rumex confertus*, *Polygonum aviculare* as well as single species from Scrophulariaceae – *Dodartia orientalis*, Cannabaceae – *Cannabis sativa*, Lamiaceae – *Marrubium vulgare* and Plantaginaceae – *Plantago media* were recorded, together accounting for approximately 2.5%.

In the shrub layer, unlike the first, second, and third populations, *Tamarix laxa* was recorded.

Within the desert zone, in comparison with the other studied populations, a dominance of steppe-type geographical ranges was established. As a result, 13 geographical elements characteristic of the region were identified within this territory (Table 5).

Figure 6
Community of the central floodplain in the desert zone Populus nigra – Melilotus albus, June, 2025

Table 5
Distribution of plant species by geographical ranges for the fourth population

Range group	Floral elements	Number of species	% of the total number
Boreal forest		21	55.2
	Eurasian	11	28.9
	Euro-Siberian	5	13.1
	European	3	7.8
	Holarctic	2	5.2
Steppe		13	34.2
	Pontic	1	2.6
	Ancient Mediterranean	8	21
	Mediterranean	1	2.6
	Asian	1	2.6
	Central Asian	1	2.6
	Caspian	1	2.6

Continuation of the table

Range group	Floral elements	Number of species	% of the total number
		4	10.5
Adventive ruderal (Pluriregional)	North American	2	5.2
	American	1	2.6
	Pluriregional	1	2.6
Total		**38**	**100**

Within the flora of the fourth population, the boreal forest group of ranges is dominated by Eurasian species – 11 species (28.9%), including *Populus nigra*, *Carex acuta*, *Carex melanostachya*, *Glycyrrhiza aspera* and *Melilotus albus*. The Euro-Siberian element comprises 5 species 13.1%, such as *Rubus caesius*, *Centaurea scabiosa*, *Linaria vulgaris* and *Rumex confertus*. European elements account for 3 species 7.8% – *Salix alba*, *Leonurus cardiaca*, *Stachys palustris*, *Lotus corniculatus*. The Holarctic element includes 2 species 5.2%: *Polygonum aviculare* and *Sonchus arvensis.*

In the steppe group of ranges, the most significant is the Ancient Mediterranean element, represented by 8 species 21%*: Eremopyrum orientale, Allium lineare, Glycyrrhiza glabra, Medicago falcata, Alhagi pseudalhagi, Atriplex cana, Bassia prostrata, Tamarix ramosissima.* Other range elements are represented by single species: Asian element – *Cannabis sativa* (1 species; 2.6%*);* Mediterranean element – *Populus alba* (1 species; 2.6%), Central Asian element – *Dodartia orientalis* (1 species; 2.6%), Caspian element – *Artemisia lercheana* (1 species; 2.6%).

The adventive ruderal group includes species of various origins: North American element – 2 species (5.2%): *Acer negundo*, *Elaeagnus commutata*;American element – *Xanthium spinosum* (1 species; 2.6%), Pluriregional element – *Convolvulus arvensis* (1 species; 2.6%). Overall, the territory where the fourth population is located belongs to the Saharo – Gobian floristic region, the Irano – Turanian subregion, the North Turanian province and the Caspian lowland subprovince. This is confirmed by the predominance of steppe and Ancient Mediterranean floristic elements within the flora.

According to Darbaeva & Chukalina (2011), communities dominated by *Populus nigra* and *Populus alba* prevailed in the floodplain poplar forests of the middle reaches of the Zhaiyk River; however, their floristic composition was presented in a generalized form, without differentiation by natural zone. The present study, based on 26 geobotanical relevés conducted along a gradient from steppe to desert, documents changes that have occurred in these communities: an expansion of the ecological – coenotic amplitude of several species – in particular, *Rubus caesius* and *Melilotus albus* – previoussly unrecorded in the desert zone, as well as intensified development of *Glycyrrhiza glabra* in the semi-desert zone under the influence of increased spring flood events in recent years. The obtained data thus reflect the dynamics of floristic composition against the backdrop of shifting hydrological conditions.

The influence of latitudinal zonation on the species composition of phytocoenoses is analyzed in detail in the chorological section of the present study. It was established that from north to south – from the steppe to the desert zone – the proportion of boreal-forest floristic elements consistently decreases: from 72.7% in the first population (steppe zone) to 55.2% in the fourth population (desert zone). Concurrently, the share of steppe and Ancient Mediterranean elements increases from 20.3% to 34.2%. Species absent from northern populations – including *Tamarix ramosissima*, *Bassia prostrata*, *Alhagi pseudalhagi*, *Dodartia orientalis* and *Artemisia lercheana* – were recorded exclusively in the desert zone. These findings confirm the ecotonal character of the region's floodplain forests, which develop at the interface of boreal and arid floristic complexes.

Comparison with Russian data was conducted with reference to studies carried out in adjacent territories. The closest floristic analogues are the floodplain poplar forests of the Ural River valley on the Russian side (Orenburg Region), described by Chibilev et al. (2023), as well as investigations of the chalk uplands of the Sub-Ural region Golovanov & Yamalov (2025). The chorological structure of the flora of the Zhaiyk floodplain communities is broadly consistent with data reported for the Russian sector of the basin, with Eurasian and Holarctic elements of the boreal group predominating and a substantial contribution of Pontic and Ancient Mediterranean species. At the same time, the Kazakhstani sector is distinguished by a markedly higher proportion of arid floristic elements – Caspian, Central Asian, and Irano-Turanian – reflecting the more pronounced aridization of the climate in the southward direction and underscoring the significance of the studied communities as refugia of boreal flora within an arid landscape matrix.

Conclusion

As a result of the comprehensive ecological-phytocoenotic and floristic study of the floodplain and ravine forests of the Zhaiyk River within the western region Kazakhstan, four populations of the genus *Populus* L. were identified and characterized, represented by the species *Populus alba, Populus nigra, Populus tremula, and Populus canescens*. The studied populations are distributed along a latitudinal gradient of natural zones – from steppe to desert – which determines significant differences in their floristic composition, phytocoenotic structure, and ecological growing conditions.

Based on 26 geobotanical relevés, eight plant associations were distinguished: *Populus canescens – Convallaria majalis*, *Populus alba – Carex vulpina*, *Populus nigra – Rubus caesius*, *Populus tremula – Aegopodium podagraria*, *Populus alba – Glycyrrhiza glabra*, *Populus nigra – Bromopsis inermis*, *Populus nigra – Melilotus albus*, *Populus nigra – Pseudosophora alopecuroides*.

The phytocoenoses are characterized by pronounced vertical stratification, high floristic diversity, and a mosaic vegetation structure. The total number of vascular plant species in individual communities ranges from 16 to 55.

Chorological analysis showed that boreal forest floristic elements (Eurasian, Euro-Siberian, European, and Holarctic) dominate in all four populations. At the same time, a clear geographical pattern was revealed: from north to south – from the steppe to the desert zone – the proportion of boreal species consistently decreases (from 72.7% in the first population to 55.2% in the fourth), whereas the share of steppe and Ancient Mediterranean elements increases (from 20.3% to 34.2%). This confirms the ecotonal character of the region's floodplain forests, formed at the junction of boreal and arid floristic complexes.

In the desert zone, an expansion of the ecological–coenotic amplitude of several species was recorded under the influence of changes in the hydrological regime. In particular, following strong floods in recent years, *Rubus caesius* began to spread within the central floodplain together with representatives of the genus *Populus*, indicating restructuring of plant community structure. The significant development of *Glycyrrhiza glabra* in the semi-desert zone also points to increased spring moisture in floodplain habitats.

It should also be noted that *Melilotus albus* was newly recorded in the desert zone after the passage of floodwaters. This finding may indicate an expansion of the species' ecological amplitude and its capacity to colonize extreme environments.

The obtained data substantially supplement existing knowledge on the structure, floristic composition, and geographical distribution of poplar forests in Western Kazakhstan

Author contributions

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Conflict of interest

All authors are aware of the article's content and declare no conflict of interest.

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