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Syntaxonomy of riparian forests of the lower reaches of the Amudarya River

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Keywords: Amudarya, Middle Asia, tugai forests, phytosociology, *Populetea euphratica*.

Summary. We present the diversity of riparian poplar (*Populus euphratica*, *P. pruinosa*) forests of the Lower Amudarya from the standpoint of floristic classification. We validated the names of class *Populetea euphratica* and order *Populetales euphratica* and described three new associations belonging to the alliance *Populion euphraticae* from the studied region. The class *Populetales euphratica*, order *Populetales euphratica* and alliance *Populion euphraticae* represent valley poplar forests of arid regions of Eurasia and North Africa. The main diagnostic feature of the class is the dominance of poplars from the subgenus *Turanga* (*Populus euphratica*, *P. pruinosa*). The association *Glycyrrhiza glabrae–Populetea pruinosa* ass. nov. unites tugai forests of the Lower Amudarya dominated by *Populus pruinosa* above the Tuyamuyun hydrosystem, as well as in the more watered south-eastern part of the river delta. The association *Tamarici ramosissimae–Populetea euphraticae* ass. nov. represents forests widely distributed in the Amudarya lower basin. The association *Zygophyllo oxiani–Populetea euphraticae* ass. nov. represents tugai forests of the Amudarya delta, where ecosystem degradation is most clearly manifested. The first compiled Prodrum of vegetation of riparian forests of the Amudarya includes one class and order, two alliances and 5 associations. Poplar forests need to be protected which requires the creation of new biospheres.

Синтаксономия долинных лесов нижнего бассейна Амударьи

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Ключевые слова: Амударья, Средняя Азия, тугайные леса, флористическая классификация растительности, *Populetea euphratica*.

Аннотация. Представлена флористическая классификация растительности тугайных тополевых (*Populus euphratica*, *P. pruinosa*) лесов бассейна Нижней Амударьи. Валидизировано название класса *Populetea euphraticae* и порядка *Populetales euphraticae*, в составе союза *Populion euphraticae* на исследованной территории описаны три новые ассоциации. Класс *Populetales euphraticae*, порядок *Populetales euphraticae* и союз *Populion euphraticae* представляют долинных тополевых леса аридных регионов Евразии и Северной Африки, диагностирующиеся доминированием тополей подрода *Turanga* (*Populus euphratica*, *P. pruinosa*). Ассоциация *Glycyrrhiza glabrae–Populetea pruinosa* ass. nov. объединяет тугайные леса Нижней Амударьи с

доминированием *Populus pruinosa*, которые распространены выше Туямуюнского гидроузла, а также в более обводнённых ландшафтах юго-восточной части дельты реки. Ассоциация *Tamarici ramosissimae*–*Populetum euphraticae* ass. nov. представляет леса, широко распространённые в бассейне Нижней Амударьи. Ассоциация *Zygophyllo oxiani*–*Populetum euphraticae* ass. nov. включает преимущественно тугайные сообщества дельты Амударьи, где наиболее ярко проявляются процессы деградации растительности. Впервые составлен продромус растительности тугайных лесов Амударьи, включающий один класс, порядок и союз в составе 5 ассоциаций. Тополевые леса региона нуждаются в сохранении в составе новых особо охраняемых территорий.

Introduction

Increasing desertification processes and associated transformation of natural ecosystems in arid areas lead to many environmental problems (Verón et al., 2006; Huang et al., 2017). As a consequence of climate aridization and increasing anthropogenic pressure, water flow regulation and intensive use of resources, the natural vegetation of the large rivers valleys is degrading on the territory of Uzbekistan. Riparian communities, primarily poplar forests, are among the most threatened types in the Amudarya, Syrdarya and Zeravshan valleys (Shcherbakov, Kulmedov, 2015).

Tugai vegetation represents a complex of communities developing in river valleys of all landscape zones, mainly in plain desert. It has long been the object of close scientific attention (Korovin, 1961; Arifkhanova, 1967; Bakhiev, 1985; etc.). To date, a detailed traditional dominant classification of riparian forests and shrubs has been developed (Mailun, 1973).

Our knowledge of valley poplar forests in Central Asia from the standpoint of floristic classification is fragmentary. These studies began in 1994 in the Lower Amudarya when 5 alliances and 5 associations were described that distinguish dominant shrubs and trees (Bakhiev et al., 1994). In 1995, these works led to assignment of poplar forests to the alliance *Populion aurianae* Golub et Kuzmina in Bakhiev et Golub 1995 including the only association *Populetum aurianae* Golub et Kuzmina in Bakhiev et Golub 1995 (Bakhiev, Golub, 1995). In the same year, N. V. Sinelnikova described tugai communities in the Amudarya Reserve in Turkmenistan (Sinelnikova, 1995) assigning them to the association *Eriantho ravennae*–*Populetum euphraticae* Sinelnikova 1995. In 2001, the alliance *Populion euphraticae* Golub in Barmin 2001 was described (Barmin 2001). The alliance *Elaeagno angustifoliae*–*Populion pruinosa* A. Nowak, M. Nobis, S. Nowak, M. Gębala, A. Nobis 2017 was described on the territory of the Tigrovaya Balka Reserve (Tadzhikistan) including a single association *Populetum pruinosa* A. Nowak,

M. Nobis, S. Nowak, M. Gębala, A. Nobis (Nowak et al., 2017). In all cited publications both shrub and forest communities were assigned to the class *Nerio–Tamaricetea* Br.-Bl. et Bolós 1957.

During the last three years, we have collected data enough to assess the diversity of riparian forest vegetation of the Lower Amudarya. Previously, we analyzed changes in the floristic composition and structure of tugai communities along main ecological gradients (Korolyuk et al., 2024) to identify the groups of plant species indicating different levels of soil salinity and moisture, as well as an anthropogenic press and succession status. These species can be used both for recognizing different riparian communities and their classification.

This paper presents the syntaxonomical diversity of tugai forests in the Lower Amudarya basin.

Natural conditions of the region

The Lower Amudarya basin is located between Western Uzbekistan and Northern Turkmenistan, bordering the Aral Sea in the north. The study area covers approximately 30 000 km². Located in the center of the Eurasian continent, afar of the oceans, the Amudarya basin is characterized by a continental climate with high heat availability, typical of a southern desert. Annual precipitation does not exceed 100 mm. Annual evaporation reaches 1800 mm. In the middle of summer there are almost no rains, which leads to summer pause of biota development. The average annual temperature ranges from + 10.6 to + 13.4. The annual sum of positive temperatures reaches 5000–5500, and up to 6000 in the extreme south and in the desert (White et al., 2014; Dukhovny, 2018). The main economic activity in the area is livestock and arable farming. Agricultural crops include cotton, wheat, rice, corn, and alfalfa (Zan et al., 2022).

Materials and methods

We involved into analysis 223 relevés of forest communities from the Republic of Karakalpakstan, Bukhara and Khorezm provinces. Data processing

was carried out using IBIS 7.2 program (Zverev, 2007). We used modern approaches of floristic classification. Both differences in floristic composition and dominant plants are traditionally used to classify species-poor communities with obvious dominants. This category also includes riparian forests dominated by species of poplars from the turanga group, *Populus pruinosa* and *P. euphratica*. At the same time, species diversity of the studied phytocenoses is low averaging 8–9 species per relevé. We distinguished associations based on the homogeneity of species composition and dominants of the tree layer, as well as on the expression of diagnostic species which were identified earlier on the basis of formalized numerical analysis (Korolyuk et al., 2024).

Relevés were made on 20*20 m plots. In the tables, projective covers of species are given on the following scale: + = <1 %, 1 = 1–4 %, 2 = 5–9 %, 3 = 10–24 %, 4 = 25–49 %, 5 = 50–74 %, 6 = 75–100 %. The nomenclature of the species followed POWO (2025). The nomenclature of syntaxa is given according to the rules of the “International Code of Phytosociological Nomenclature” – ICPN (Theurillat et al., 2021).

Results and discussion

The first task we solved was to determine the position of riparian forests in the system of higher units of floristic classification. As we noted above, all syntaxa described from the Amudarya valley were referred by the authors to the class **Nerio-Tamaricetea** Br.-Bl. et Bolos 1957. This class is currently treated as circum-Mediterranean and Macaronesian intrazonal types of shrub communities (Mucina et al., 2016) with diagnostic taxa *Arundo donax*, *Clematis campaniflora*, *Triplidium ravennae*, *Gomphocarpus fruticosus*, *Imperata cylindrica*, *Lonicera biflora*, *Nerium oleander*, *Panicum repens*, *Periploca graeca*, *Phoenix theophrasti*, *Polygonum equisetiforme*, *Salix atrocinerea*, *S. salviifolia*, *Securigera tinctoria*, *Tamarix africana* var. *africana*, *T. africana*, *T. boveana*, *T. canariensis*, *T. dalmatica*, *T. gallica*, *T. hampeana*, *T. parviflora*, *T. smyrnensis*, *T. tetrandra*. As can be seen from the diagnosis, this class comprises predominantly tamarix, less frequently willow communities and coenoses with other shrub species.

H. Akhani and L. Mucina (2015) described the eastern ecological analog of this class by. The class **Tamaricetea arceuthoidis** Akhani et Mucina 2015 in the authors' interpretation represents the coastal and adjacent shrub vegetation of the Iran-

Turan region, Central Asia and the Lower Volga valley. The dominant species are those of the genus *Tamarix* which indicate a high groundwater table under conditions of arid climate and moderate soil salinity. The authors included *Caroxylon imbricatum*, *Desmostachya bipinnata*, *Elaeagnus angustifolia*, *Nerium oleander*, *Ochradiscus aucheri*, *Phragmites australis*, *P. karka*, *Prosopis koelziana*, *Suaeda fruticosa*, *S. physophora*, *Tamarix aphylla*, *T. arceuthoides*, *T. aucheriana*, *T. dubia*, *T. hispida*, *T. kermanensis*, *T. kotschyi*, *T. mascatensis*, *T. ramosissima*, *T. rosea*, *T. stricta*, *Vitex agnus-castus*, *Ziziphus spina-christi* as the character species of the class. The widespread in the Amudarya valley tamarix communities can also be referred to this class.

In floristic classification, along with diagnostic (differentiating, character) species, physiognomic traits are also used to distinguish classes. Based on the dominance of different life forms, classes are recognized often close in species composition. From these positions, the studied forests should be considered as part of the class **Populetea euphraticae** Zohary 1962 nom. inval. This class and its single order **Populetales euphraticae** Zohary 1962 nom. inval. represent riparian poplar forests of arid regions of the Sahara-Gobi Desert region. It was originally described from Israel and Jordan (Zohary, 1962). The known eastern limit of the class range is the Alashan Gobi (Kürschner, 2004). The main diagnostic feature of the class is the dominance of poplars from the subgenus *Turanga* (Bunge) Dode represented by two species in the studied area, *Populus euphratica* (syn. *P. ariana*, *P. diversifolia*) and *Populus pruinosa* (Skvortsov, 2010). Tree dominance serves as the main feature for separating poplar forests from shrub communities with similar species composition, the latter should be considered as part of the class **Tamaricetea arceuthoidis**.

In the Lower Amudarya basin 4 poplar communities were identified differing in species occurrence and tree canopy dominants (Table 1). These types were compared with previously described syntaxa. As a result of this analysis, we described three new associations and two variants.

Description of syntaxa

Class **Populetea euphratica** Zohary ex Korolyuk, Shomurodov et Khabibullaev **class nov.**

Nomenclatural type (holotypus) – order **Populetales euphraticae** Zohary ex Korolyuk, Shomurodov et Khabibullaev **ord. nov.**

Table 1. Synoptic table of syntaxa representing riparian poplar forests of the Lower Amudarya (constancies of species are given in percents)

Number of relevés	41	48	40	31
Syntaxa	1	2	3	4
<i>Populus euphratica</i>	44	100	100	100
<i>Populus pruinosa</i>	100	100	18	19
<i>Calamagrostis pseudophragmites</i>	29	8	8	6
<i>Suaeda altissima</i>	7	10	13	97
<i>Zygophyllum oxianum</i>	12	2	13	84
<i>Leymus multicaulis</i>	2	10	13	58
<i>Halostachys caspica</i>	12	8	10	48
<i>Tamarix hispida</i>	2	2	3	61
<i>Limonium otolepis</i>	5	.	.	58
<i>Asparagus brachyphyllus</i>	22	27	3	.
<i>Elaeagnus angustifolia</i>	49	48	45	26
<i>Phragmites australis</i>	49	81	55	29
<i>Tamarix ramosissima</i>	88	83	95	81
<i>Glycyrrhiza glabra</i>	68	65	50	65
<i>Caragana halodendron</i>	32	54	58	68
<i>Aeluropus littoralis</i>	54	46	48	45
<i>Cynanchum acutum</i>	34	48	38	45
<i>Alhagi pseudalhagi</i>	41	17	25	23
<i>Apocynum venetum</i>	20	17	8	3
<i>Tripidium ravennae</i>	10	8	3	.
<i>Clematis orientalis</i>	5	8	10	.
<i>Caroxylon scleranthum</i>	10	.	10	.
<i>Sphaerophysa salsula</i>	2	.	5	10
<i>Bromus tectorum</i>	12	2	.	.
<i>Karelinia caspia</i>	2	.	.	10

Note. 1–2 – association *Glycyrrhizo glabrae*–*Populetum pruinosa*: 1 – variant *typica*; 2 – variant *Populus euphratica*; 3 – association *Tamarici ramosissimae*–*Populetum euphraticae*; 4 – association *Zygophyllo oxiani*–*Populetum euphraticae*. Cells which have differentiating significance in terms of constancy are marked in grey.

Diagnostic species: *Populus euphratica* (dom.), *P. pruinosa* (dom.), *Aeluropus littoralis*, *Cynanchum acutum*, *Elaeagnus angustifolia*, *Tripidium ravennae*, *Glycyrrhiza glabra*, *Caragana halodendron*, *Phragmites australis*, *Tamarix ramosissima*, *T. karakalensis*, *Apocynum venetum*.

Rejected name: *Populetea euphraticae* Zohary 1962 (ICPN, art. 2b).

The class represents valley poplar forests of arid regions of Eurasia and North Africa. The main diagnostic feature of the class is the dominance of poplars from the subgenus *Turanga*. Communities of the class are widely distributed in the river valleys of Central Asia. The class is represented by a single order.

Order *Populeitalia euphraticae* Zohary ex Korolyuk, Shomurodov et Khabibullaev **ord. nov.**

Nomenclature type (holotypus) – alliance *Populion euphraticae* Golub in Barmin 2001.

Diagnostic species: *Populus euphratica* (dom.), *P. pruinosa* (dom.), *Aeluropus littoralis*, *Cynanchum acutum*, *Elaeagnus angustifolia*, *Tripidium ravennae*, *Glycyrrhiza glabra*, *Caragana halodendron*, *Phragmites australis*, *Tamarix ramosissima*, *T. florida*, *Apocynum venetum*.

Rejected name: *Populeitalia euphraticae* Zohary 1962 (ICPN, art. 2b).

Alliance *Populion euphraticae* Golub in Barmin 2001.

Diagnostic species: *Populus euphratica* (dom.), *Populus pruinosa* (dom.).

Rejected name: *Populion euphraticae* Zohary 1962 (ICPN, art. 2b).

The alliance represents riparian forests of the Lower Amudarya valley and its delta. V. B. Golub (Bakhiev, Golub, 1995) made the first attempt to describe an alliance representing riparian valley forests with proposed name *Populion arianae*. The alliance had no differentiating (diagnostic) species and contained the only association within it, *Populetum arianae* Golub et Kuzmina in Bakhiev et Golub 1995, a requirement of syntaxon validity since 1980 (Theurillat et al., 2021). Its ecological analogs in the Upper Amudarya valley belong to the alliance *Elaeagno angustifoliae*–*Populion pruinosa* A. Nowak et al. 2017 with the following diagnostic combination: *Arundo donax*, *Karelinia caspia*, *Limonium reniforma*, *Saussurea kabadiana*.

Association *Glycyrrhizo glabrae*–*Populetum pruinosa* **ass. nov.** (Table 2, relevés 1–24).

Nomenclature type (holotypus) – Table 2, relevé 2 (field number 22-006): Republic of Uzbekistan, Bukhara oblast, Karakul district, southwest of Gurgurtli village, the Amudarya terrace, 40°22'9.2"N, 62°21'47"E, 26 VI 2022, author – A. Yu. Korolyuk.

Diagnostic species: *Populus pruinosa* (dom.), *Cynanchum acutum*, *Elaeagnus angustifolia*, *Glycyrrhiza glabra*.

rhiza glabra, *Phragmites australis*, *Tamarix ramosissima*.

The association unites tugai forests of the Lower Amudarya dominated by *Populus pruinosa*, a wide-spread type of riparian communities which prevail

in the Amudarya valley above the Tuyamuyun hydrosystem, as well as in the more watered south-eastern part of the river delta (Fig. 1). It is represented by two variants.

Table 2. Association *Glycyrrhizo glabrae–Populetum pruinosa* ass. nov.

Variant	<i>typica</i> (a)												<i>Populus euphratica</i> (b)												Species constancy	
Date	25 IV 2022	26 IV 2022	26 IV 2022	27 IV 2022	28 IV 2022	29 IV 2022	21 IV 2023	22 IV 2023	23 IV 2023	24 IV 2023	27 IV 2022	01 V 2022	25 IV 2022	27 IV 2022	29 IV 2022	01 V 2022	22 IV 2023	23 IV 2023	28 IV 2022	29 IV 2022	26 IV 2022	27 IV 2022	20 IV 2023	23 IV 2023		
Latitude (°)	40°34'45.1"	40°22'9.2"	40°36'57.5"	41°16'35.9"	41°58'48.5"	42°0'14.7"	42°23'13.1"	42°30'58.1"	42°34'16.6"	43°5'23.8"	41°16'30.8"	42°16'58.4"	40°34'29.2"	41°16'23.7"	42°0'3.4"	42°18'33.2"	42°30'59.8"	42°36'43.9"	41°58'44.1"	42°0'17.8"	40°22'9.5"	41°16'34.6"	42°28'24.1"	42°34'11.6"		
Longitude (°)	62°7'45.1"	62°21'47"	62°7'19.1"	61°17'25.2"	60°24'15.7"	60°17'46.3"	59°35'8.6"	59°26'42.7"	59°18'43.1"	59°10'2.1"	61°17'50.7"	60°1'6.6"	62°8'4.4"	61°18'5.1"	60°17'59.1"	59°56'2.5"	59°26'31.2"	59°17'5.9"	60°23'3.2"	60°17'59.9"	62°21'52.1"	61°18'2.9"	59°32'2.4"	59°19'16.9"		
Trees cover (%)	80	50	30	40	60	50	30	30	20	55	25	40	50	45	50	50	25	50	30	35	50	35	60	40		
Scrubs and herbs cover (%)	0	40	15	20	1	17	5	20	5	5	15	40	35	45	20	30	10	20	40	1	25	20	20	30		
Number of species	10	9	11	8	8	10	9	10	9	13	11	8	13	15	10	11	11	11	10	11	9	9	9	8		
Field relevé number	22-003	22-006	22-015	22-026	22-028	22-036	23-005	23-024	23-034	23-049	XS22-022	XS22-060	22-002	22-020	22-042	22-066	23-025	23-037	BH22-003	BH22-007	XS22-005	XS22-020	XS23-014	XS23-034	a b	
Table relevé number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24		

Diagnostic species of variant *Populus euphratica*

<i>Populus euphratica</i>	+	+	.	+	.	+	.	1	+	1	.	.	2	2	2	2	3	3	3	3	3	4	3	4	III	V
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Diagnostic species of the ass. *Glycyrrhizo glabrae–Populetum pruinosa*

<i>Populus pruinosa</i>	6	4	4	4	5	5	4	4	3	5	4	4	4	4	4	2	4	3	3	4	2	4	3	V	V	
<i>Tamarix ramosissima</i>	+	2	+	1	+	1	+	1	1	+	3	+	1	+	+	.	1	1	3	+	1	1	+	+	V	V
<i>Glycyrrhiza glabra</i>	+	3	1	3	.	2	1	3	1	.	+	2	1	2	3	.	+	3	.	+	1	3	3	1	V	V
<i>Elaeagnus angustifolia</i>	.	3	+	+	.	2	1	1	1	1	.	+	.	1	2	+	1	+	.	+	3	.	+	+	IV	IV
<i>Phragmites australis</i>	+	+	.	.	+	+	.	.	+	+	.	4	4	4	+	2	+	+	+	+	+	1	.	4	III	V
<i>Cynanchum acutum</i>	+	+	+	.	.	+	.	.	.	+	.	.	+	+	+	+	+	.	+	.	+	+	+	+	III	V

Diagnostic species of the class *Populetea euphraticae*, the order *Populetales euphraticae* and the alliance *Populion euphraticae*

<i>Aeluropus littoralis</i>	.	.	.	2	+	+	.	.	+	+	+	+	+	.	.	+	+	IV	IV								
<i>Caragana halodendron</i>	.	.	.	.	+	.	.	.	.	1	1	.	.	2	.	3	.	+	4	+	.	1	.	.	II	III	
<i>Apocynum venetum</i>	+	+	1	.	.	.	.	.	.	.	.	2	+	.	+	+	.	.	.	.	+	.	.	.	II	II	
<i>Triplidium ravennae</i>	.	.	+	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	1	.	.	.	I	I

Other species

<i>Alhagi pseudalhagi</i>	.	.	.	+	.	+	+	+	1	.	+	.	.	+	.	.	2	.	+	.	.	.	.	III	II
<i>Asparagus brachyphyllus</i>	+	.	.	.	+	.	.	.	.	.	+	.	+	+	.	.	.	.	+	.	.	+	.	II	II
<i>Calamagrostis pseudophragmites</i>	+	.	3	.	+	.	.	.	.	+	.	.	.	.	.	.	.	.	+	.	.	.	.	II	I
<i>Clematis orientalis</i>	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	I	I
<i>Halostachys caspica</i>	.	.	+	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	.	.	.	.	I	I

Note. Species with low occurrence: *Astragalus orbiculatus* (10 +), *Bassia hyssopifolia* (11 +), *Bromus tectorum* (7 +), *Cirsium arvense* (14 +), *Climacoptera lanata* (19 +), *Girgensohnia oppositiflora* (23 +), *Lactuca serriola* (11 +), *Lappula* sp. (8 +, 17 +), *Leymus multicaulis* (16 +), *Limonium otolepis* (11 1), *Rhaponticum repens* (10 +), *Sphaerophysa salsula* (10 +), *Suaeda altissima* (18 +, 20 +), *Tamarix hohenackeri* (9 +), *Tephrosia subdentata* (7 +, 8 +), *Zygophyllum oxianum* (11 +, 12 +).

Localities: **Khorezm region, Khazorasp district:** 1, 3, 13 – tugai massif “Shurtugay”; 4, 11 – south-east of Kichik-Dzhuvarkhaz village.

Bukhara region, Karakul district: 2, 21 – south-west of Gugurtli village.

Karakalpakstan, Amu Darya district: 5, 6, 15, 19, 20 – Reserve “Badaytugai”; 12 – north-west of Shilpik village; 16 – south of Nazarkhan village. **Khojeyla district:** 7 – southern outskirts of Nukus city; 9 – south-west of Sadvinsovkhoz Pobeda village; 23 – east of Pristin village. **Nukus district:** 8, 17, 24 – south-west of Zhdanov village. **Kungirad district:** 10 – south-west of Porlytau village. **Turtkul district:** 14, 22 – south-east of Akamysh village. **Kanlikul district:** 18 – east of Lekinau village.



Fig. 1. Association *Glycyrrhiza glabrae*–*Populetum pruinosa*, Bukhara region, Gugurtli village (Photo by B. S. Khabibullaev).

Variant *typica* (Table 2, relevés 1–12) features *Populus pruinosa* dominance in the stand. In general, the variant is associated with less saline, often sandy soils.

Variant *Populus euphratica* (Table 2, relevés 13–24) is characterized by co-dominance of two poplar species. It represents a widespread type of riparian forest communities and occupies a transitional position to the association *Populetum aurianae*. It was recorded in all studied areas (Fig. 2), but in the delta part it becomes rare, here its cenoses are confined to drier habitats, often with sandy soils.

Association *Tamarici ramosissimae*–*Populetum euphraticae* ass. nov. (Table 3, relevés 1–12).

Nomenclatural type (holotypus) – Table 3, relevé 7 (field number 23-048): Republic of Uzbekistan, Karakalpakstan, Kungirad district, southwest of Porlytau village, the Amudarya bank, 59°10'4.4"N, 43°5'17.1"E, 24 IV 2023, author – A. Yu. Korolyuk.

Rejected name: *Populetum arianae* Golub et Kuzmina in Bakhiev et Golub 1995 (ICPN, art. 8).

Diagnostic species: *Populus euphratica* (dom.), *Caragana halodendron*, *Tamarix ramosissima*.



Fig. 2. Association *Populeum aurianae*, Karakalpakstan, Lower Amudarya State Biosphere Reserve (Photo by B. S. Khabibullaev).



Fig. 3. Association *Tamarici ramosissimae*–*Populeum euphraticae*, Karakalpakstan, Porlytau village (Photo by B. S. Khabibullaev).

The association unites forests widely distributed in the Amudarya lower basin (Fig. 3). They represent the association of the central type. These communities in many areas developed as a result of riparian forest degradation associated with the initial stages of salinization, when increasing groundwater salinity leads to a decrease in the abundance of less halotolerant *Populus pruinosa*. At the same time, the upper soil horizons remain weakly saline accounting for low occurrence of halophytic plants diagnosing the association *Zygophyllo oxiani*–*Populetea euphraticae*. These processes are actively manifested in the Amudarya delta. Communities of the association are also found upstream, where river runoff is not regulated and water withdrawal for irrigation is less significant. Here, forests dominated by poplar grow in drier habitats characterized by increased salinity.

Association *Zygophyllo oxiani*–*Populetea euphraticae* **ass. nov.** (annex, table 3, relevés 13–24).

Nomenclature type (holotypus) – Table 3, relevé 23 (field number XS23-071): Republic of Uzbekistan, Karakalpakstan, Karauzyak district, north-east of Koibak village, 59°59'5.8"N, 42°47'22.5"E, 26 IV 2023, authors – K. F. Shomurodov, B. S. Khabibullaev.

Diagnostic species: *Halostachys caspica*, *Leymus multicaulis*, *Limonium otolepis*, *Suaeda altissima*, *Tamarix hispida*, *Zygophyllum oxianum*.

The association represents tugai forests of the Amudarya delta where ecosystem degradation is most clearly manifested (Fig. 4). They are formed as a result of progressive salinization caused by climatic changes and anthropogenic pressure, as we wrote above. This is reflected in diagnostic combination with the predominance of halophytic plants.

Taking into account our data, as well as previously published works, the prodromus of tugai forests of the Amudarya on the territory of Uzbekistan, Turkmenistan and Tajikistan is as follows.

Class *Populetea euphraticae* Zohary ex Korolyuk, Shomurodov et Khabibullaev **class nov.**

Order *Populetales euphraticae* Zohary ex Korolyuk, Shomurodov et Khabibullaev **ord. nov.**

Alliance *Populion euphraticae* Golub in Barmin 2001

Ass. *Eriantho ravennae*–*Populetea euphraticae* Sinelnikova 1995

Ass. *Glycyrrhiza glabrae*–*Populetea pruinosa* **ass. nov.**

Var. *typica*

Var. *Populus euphratica*

Ass. *Tamarici ramosissimae*–*Populetea euphraticae* **ass. nov.**

Ass. *Zygophyllo oxiani*–*Populetea euphraticae* **ass. nov.**

Alliance *Elaeagno angustifoliae*–*Populion pruinosa* A. Nowak et al. 2017

Acc. *Populetea pruinosa* A. Nowak et al. 2017

Conclusion

The peculiarity of vegetation of large river valleys of Central Asia is largely determined by riparian forests. Communities dominated by poplars (*Populus euphratica*, *P. pruinosa*) are among the most threatened types, the reasons being centuries-old economic use of valley landscapes, as well as desertification processes intensified in recent decades. Comparative analysis of our data and few publications allowed us to describe the diversity of riparian forests of the Amudarya from the standpoint of floristic classification. Within the class *Populetea euphraticae* and order *Populetales euphraticae*, 5 associations have been described to date, 4 of which occur in the lower reaches of the river and its delta. They are referred to the alliance *Populion euphraticae*. The only association from the alliance *Elaeagno angustifoliae*–*Populion pruinosa* is given for the Upper Amudarya basin. Undoubtedly, the diversity of riparian vegetation of Central Asia is much higher than that we described. Further development of its syntaxonomic system is possible at involvement of materials from valleys of large rivers, the Syrdarya, Zeravshan, Ili and others. Poplar forests need to be protected which requires the creation of new bioreerves. This type of communities is important for organizing monitoring of natural ecosystems, especially in the Amudarya delta where desertification processes are most pronounced.

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Table 3. Associations *Tamarici ramosissimae*–*Populetum euphraticae* ass. nov. and *Zygophyllo oxiani*–*Populetum euphraticae* ass. nov.

Association	<i>Tamarici ramosissimae</i> – <i>Populetum euphraticae</i> (a)												<i>Zygophyllo oxiani</i> – <i>Populetum euphraticae</i> (b)												Species constancy	
Date	26 IV 2022	27 IV 2022	28 IV 2022	22 IV 2023	23 IV 2023	24 IV 2023	24 IV 2023	24 IV 2023	20 IV 2023	24 IV 2023	21 IV 2023	21 IV 2023	21 VII 2022	21 IV 2023	21 IV 2023	21 IV 2023	22 IV 2023	24 IV 2023	25 IV 2023	25 IV 2023	26 IV 2023	21 IV 2023	26 IV 2023	26 IV 2023		
Latitude (°)	62°21'51.1"	61°58'6"	60°23'11.1"	59°26'29.3"	59°19'10.3"	59°10'2.7"	59°10'4.4"	59°4'28.2"	59°33'14.5"	59°10'6"	59°35'29.7"	59°33'15.9"	60°1'10.2"	59°35'29.7"	59°35'34.3"	59°31'29.6"	59°20'44.8"	59°4'27"	59°3'7.4"	58°59'27"	59°59'12.1"	59°29'20.6"	59°59'5.8"	59°59'10.4"	Species constancy	
Longitude (°)	40°22'8.3"	41°29'9"	41°58'37.9"	42°31'4.8"	42°34'11.2"	43°5'15.7"	43°5'17.1"	43°34'28.5"	42°26'7.4"	43°5'16"	42°23'16"	42°26'4.9"	42°17'3.4"	42°22'59.1"	42°23'5.2"	42°28'16.3"	42°32'54.9"	43°34'33.6"	43°33'56.8"	43°27'30.2"	42°47'23.9"	42°28'24.6"	42°47'22.5"	42°47'22.5"		
Trees cover (%)	40	40	40	45	35	55	50	55	70	75	50	30	40	30	30	25	30	25	30	30	45	50	40	50		
Scrubs and herbs cover (%)	45	30	20	30	25	40	5	5	15	5	2	20	30	30	15	30	25	35	25	15	40	40	20	30		
Number of species	9	6	5	8	8	8	10	11	7	10	6	4	15	11	12	12	12	15	11	12	9	10	9	7		
Field relevé number	22-005	22-018	22-032	23-026	23-031	23-047	23-048	23-054	XS23-009	XS23-053	BH23-P03	BH23-P08	BH22-022	23-003	23-004	23-014	23-028	23-055	23-059	23-069	23-071	BH23-021	XS23-071	XS23-073		
Table relevé number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	a	b

Diagnostic species of the ass. *Tamarici ramosissimae*–*Populetum euphraticae*

<i>Populus euphratica</i>	4	4	4	4	4	5	5	5	5	6	4	4	4	4	4	4	4	4	4	4	4	5	4	5	V	V
<i>Tamarix ramosissima</i>	1	4	1	+	2	+	1	+	1	1	1	+	+	2	2	1	1	4	1	3	+	.	3	.	V	V
<i>Caragana halodendron</i>	1	.	3	.	.	3	1	1	2	1	1	+	+	3	.	.	.	1	.	3	3	.	3	.	IV	III

Diagnostic species of the ass. *Zygophyllo oxiani*–*Populetum euphraticae*

<i>Suaeda altissima</i>	.	.	.	.	.	.	.	+	.	.	.	.	+	+	1	+	1	1	1	+	1	+	+	+	I	V
<i>Halostachys caspica</i>	.	.	.	.	.	.	.	.	.	+	.	.	+	1	+	3	3	+	.	+	1	.	1	3	I	V
<i>Zygophyllum oxianum</i>	.	.	.	+	.	.	.	.	.	.	.	.	+	.	.	2	+	1	+	1	2	+	+	+	I	V
<i>Tamarix hispida</i>	.	.	.	.	.	.	.	.	.	.	.	.	+	1	1	+	.	+	3	.	1	+	3	.	IV	
<i>Limonium otolepis</i>	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	+	+	+	+	.	.	+	+	.	IV	
<i>Leymus multicaulis</i>	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	+	1	+	3	4	+	2	.	IV

Diagnostic species of the class *Populetea euphraticae*, the order *Populetales euphraticae* and the alliance *Populion euphraticae*

<i>Glycyrrhiza glabra</i>	3	.	.	4	3	4	+	.	1	+	+	3	4	1	2	+	2	.	1	1	.	1	.	.	IV	IV
<i>Aeluropus littoralis</i>	.	.	.	+	+	.	.	+	+	+	+	.	+	+	+	.	1	1	.	.	.	.	.	.	III	III
<i>Phragmites australis</i>	+	+	+	+	2	+	+	+	.	+	.	.	.	.	.	1	+	.	.	.	.	.	.	.	IV	I
<i>Elaeagnus angustifolia</i>	3	.	.	+	.	.	+	+	.	1	.	.	+	+	.	1	.	.	.	.	.	.	+	2	III	III
<i>Cynanchum acutum</i>	+	+	.	.	.	+	+	.	.	.	.	.	+	.	+	.	.	+	.	+	.	.	.	.	II	II
<i>Populus pruinosa</i>	.	.	.	.	1	+	.	.	.	.	.	.	+	.	.	.	.	1	1	.	+	.	.	.	I	II

Other species

<i>Alhagi pseudalhagi</i>	.	+	.	.	+	.	.	+	.	.	.	.	+	.	+	+	+	.	.	+	.	.	.	.	II	III
<i>Atriplex belangeri</i>	.	.	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.	+	+	.	.	.	.	+	I	II
<i>Sphaerophysa salsula</i>	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	I	I

Note. Species with low occurrence: *Apocynum venetum* (1 +, 15 +), *Asparagus brachyphyllus* (3 +), *Astragalus turkestanus* (10 +), *Calamagrostis pseudophragmites* (1 +), *Clematis orientalis* (11 +), *Karelinia caspia* (17 +), *Lappula* sp. (18 +), *Rhaponticum repens* (7 +, 10 +), *Sophora alopecuroides* (9 +), *Taraxacum bicorne* (15 +), *Taraxacum comitans* (8 +), *Tephrosia subdentata* (18 +).

Localities: **Bukhara region, Karakul district:** 1 – south-west of Gugurtli village.

Khorezm region, Khazorasp district: 2 – south of Uchuchak village.

Karakalpakstan, Amu Darya district: 3 – Reserve “Badaytugai”, 13 – north-west of Shilpik village; **Nukus district:** 4 – south-west of – Zhdanov village; 5 – south-west of Sadvinsovkhoz Pobeda village; **Kungirad district:** 6, 7, 10 – south-west of Porlytau village; **Muynak district:** 8, 18, 19 – west of Kizilzhar village; 20 – south of Shagiri village; **Khojeyla district:** 9 – east of – Pristin village; 11, 12, 14, 15, 16 – the outskirts of Nukus city; 17 – north-east of Pirzhan Khalmkradov village; 22 – south-east of Khojeyli city; 21, 23, 24 – **Karauzyak district**, north-east of Koybak village.



Fig. 4. Association *Zygophyllo oxiani*–*Populetum euphraticae*, Karakalpakstan, Karauzak region (Photo by B. S. Khabibullaev).

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