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Distribution, floristic structure and habitat requirements of the riparian forest community *Populetum talassicae* ass. nova in the Central Pamir-Alai Mts (Tajikistan, Middle Asia)

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Abstract

This paper discusses the floristic structure, distribution and habitat requirements of a new forest syntaxon, *Populetum talassicae* ass. nova. The potential range of the *Populetum talassicae* association comprises the central Pamir-Alai and Tian-Shan Mountains in Middle Asia. The biotope of this community comprises high mountain river valleys and shore zones of mountain lakes situated at elevations between 2200 and 2750 m. Phytocoenoses of the *Populetum talassicae* association are characterized by a clear predominance in the tree layer of a characteristic species of the association – *Populus talassica*. Shrubs are not so abundant; however, the undergrowth layer of the community could reach up to 60% of the total cover, consisting mainly of *Salix* spp., *Hippophaë rhamnoides*, *Lonicera stenantha*, *Juniperus semiglobosa* and *J. seravschanica*. The herbaceous layer is quite rich and has about 20 species on average. Among associated species mainly meadow, rush and marsh taxa have been noted. Regarding the considerable cover of the meadow species, the association of *Populetum talassicae* has been classified as the *Populetea laurifolio-suaveolentis* syntaxon. A new plant alliance was proposed – *Populion talassicae* all. nova with *Pedicularis dolichorhiza* and *Astragalus tibetanus* as diagnostic species. The described forest association is one of the rarest and most rapidly disappearing wood communities in Tajikistan, which means that special conservation attention is called for.

Keywords: *Populus talassica*, syntaxonomy, alpine vegetation, forest vegetation, new plant association, Middle Asia

Introduction

Tajikistan is a country located almost entirely in the central part of the Pamir-Alai Mountains – one of the main mountain systems in Middle Asia, lying on the border of the subtropical and temperate zones. Tajikistan is also one of the richest regions in plant species diversity in the former Soviet Union. According to the ten-volume study of the flora of the former Soviet Socialist Republic of Tajikistan, completed by a multi-author team and supplemented by the works of other researchers, ca. 4550 vascular plant species are known from the country [1]. This number is not final as recently some new species have been described from Tajikistan [2–6] and new records of its flora have been published [7–12]. According to literature data, ca. 30% of the entire flora of vascular plants known from Tajikistan are generally accepted as endemic of the country (endemics sensu stricto + subendemics) [1,13,14]. Some of them have been subjected to detailed biological studies [15].

Forest communities are among the relatively well-known types of vegetation in Tajikistan and Central Asia. It is possible to find data on these types of phytocoenoses, for example, in papers by Zakirov, Zapryagajeva, Ovczinnikov et al. and Stanjukovich [16–20]. However, these works do not present the complete structure of communities, their diversity from a floristic point of view, nor do they consider lateral or vertical geographic aspects of their distribution. They only represent some basic formations of vegetation determined on the basis of so-called edificators, i.e. indicator species predominating in this biotope, without distinction of separate syntaxa. Up to now detailed phytosociological studies were presented only for specified water assemblages in Tajikistan [21].

Amongst forest plants in the central Pamir-Alai Mts (Tajikistan) there are also distinct mesotrophic deciduous forests, also known as large-leaved (so-called "chernolesye"). These are communities of thermophillous and mesophillous trees and bushes. They occur mainly in the Gissar-Darvasian Range and, in part, in the Zeravshan Range. They correspond to the broad-leaved forests of Central Europe as far as biotope is concerned. These stands are formed predominantly by *Juglans regia*, *Acer turkestanicum* or *Platanus orientalis*. More often they appear at altitudes between 1200 and 2500 m, on the slopes of medium-height mountains on the northern side. Indeed, it is possible to see them at lower levels, for example in river valleys (mainly

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Platanus orientalis stands). In forests of such communities *Impatiens parviflora*, *Aegopodium tadzhikorum*, *Poa nemoralis* and *Dactylis glomerata* more often predominate [16–18,22].

In Tajikistan, a few types of communities were assigned to riparian forests with the distinction more often of two main groups, namely riparian forest (so-called "thugay") and "bielolesya" – *Betula* sp. tree stands. A thugay forest is a subtropical community of hygrophilic and thermophillous deciduous trees, mainly *Populus euphratica* (= *P. diversifolia*) and *Populus pruinosa*. In these plots *Eleagnus angustifolia*, *E. orientalis*, *Tamarix hispida*, *Glycyrrhiza glabra*, *Poa bulbosa*, *Phragmites communis*, and *Erianthus ravennae* often appear. Riparian forests develop in valleys of lower-lying areas along the rivers Syr-Daria and Amu-Daria and their tributaries (e.g. [23]). Communities of the riparian forest probably need to be considered as a member of the class *Populetea euphraticae* Zohary 1962.

Bielolesya are pledge stands of birches, willows and poplars. These communities are also considered in general within the group of forests called fine-leaved, "summer" forests or, also, deciduous. Along rivers and mountain streams the birch woods, comprising *Betula pamirica*, *B. alajica*, *B. ovczinnikovii*, *B. saposhnikovii*, *B. turkestanica*, *B. tadshikistanica*, develop. Quite often in such an admixture black poplar *Populus nigra*, as well as *Juniperus semiglobosa*, *Sorbus tianschanica*, *Lonicera coerulea*, *Trichophorum pumilum*, *Euphrasia tatarica* and *Trifolium pratense* appear. The birch forests are usually characterized by a comparatively rich herbal layer, but in Pamir, for example, around Lake Sarez – birch grow on the rocks of mountain streams where cover of a herb layer is negligible. From western Pamir a stand of *Populus pamirica* has been described which develops in the river valleys at altitudes of around 2000–3000 m. In this stand *Betula turkestanica*, *Salix shugnanica* and *Hippophaë rhamnoides* sometimes occur. In the undergrowth, *Lonicera stenantha* has a significant share.

Willow riparian forests occur in river valleys in the lowlands and medium-height mountain rivers in the Tajik Pamir-Alai Mts. Depending on the region, they are constructed, amongst others, by *Salix wilhelmsiana*, *S. excelsa*, *S. pycnostachya* and *S. iliensis* [16–19].

One of the rarest types of alluvial forest, which covers very little surface in Tajikistan and is restricted in occurrence to within the basin of Lake Iskanderkul, is a forest with a predominance of *Populus talassica* (= *P. densa*). Zakirov [16] noted that this forest is more than one hundred years old, being composed mainly of poplars and species such as *Berberis* sp., *Spiraea* sp., *Rosa* sp. and *Cotoneaster* sp. in the undergrowth. According to this author, the typical feature of this tree stand is a poor natural recovery connected with the dynamic entrance of *Salix* species into gaps after the death of poplars. The author also noted more humid variants of forest with the participation of *Polygonatum roseum*, *Dactylorhiza umbrosa* and *Epipactis* sp.

The main aim of the present work was to provide a detailed phytosociological study in the community of alluvial forests predominated by *Populus talassica*, the location of that phytocoenosis in syntaxonomic classification as well as a presentation of threats by anthropogenic impact on that type of forest in Middle Asia. Moreover, the present paper includes the current chorology of the community in the area of Tajikistan and its composition of species as well as habitat conditions for its occurrence.

Material and methods

Geobotanical studies were carried out in 2007 to 2010 within the range of *Populus talassica*, mainly in mountain stream valleys and lakes in the central Pamir-Alai mountain ranges (Fig. 1). During the field exploration, the presence of the

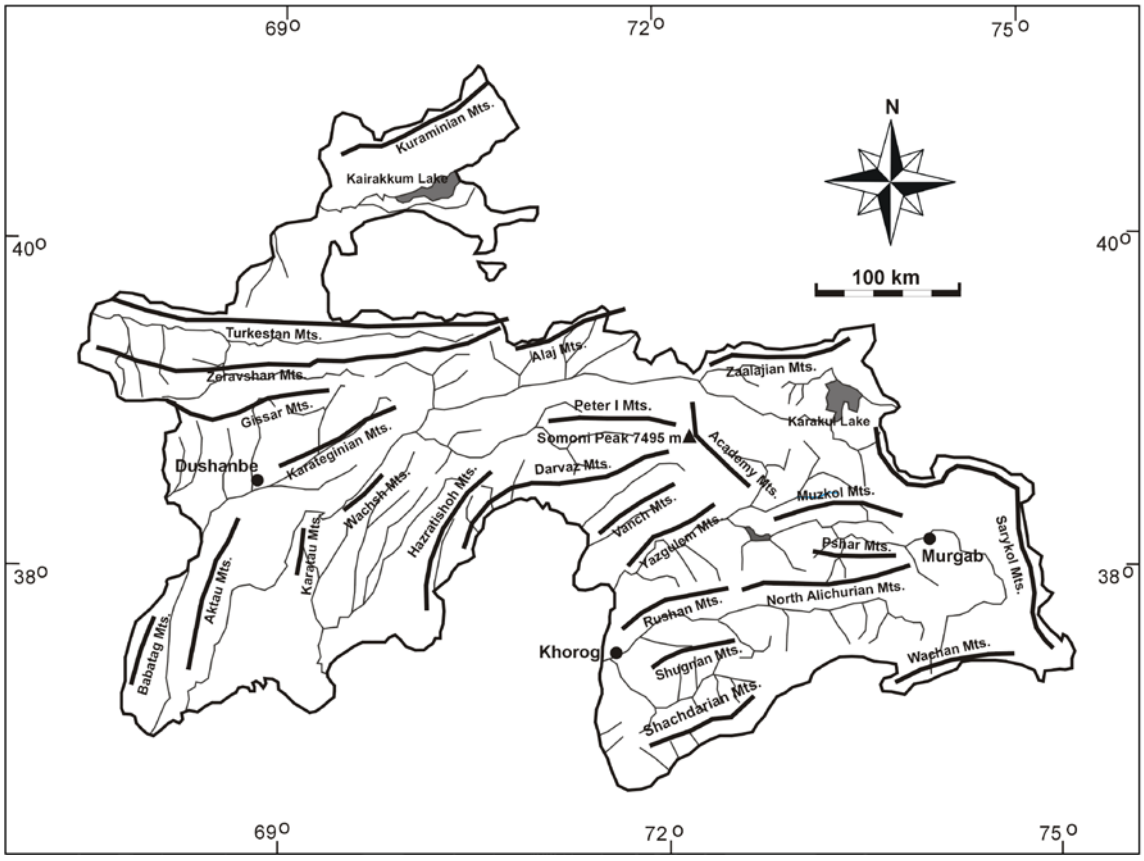

Fig. 1 The study area (Tajikistan) with main rivers, mountain ranges and cities.

vegetation plots dominated by *Populus talassica* was examined in more than 30 river valleys and along the periphery of 15 mountain lakes.

In general, 7 sites and 18 vegetation plots with *Populus talassica* occurrence were sampled using the phytosociological Braun-Blanquet approach [24]. In the Tab. 1, the total cover for tree layer (a) and sublayer (a2) was counted together.

All specimens collected are stored at the OPUN and KRA herbariums.

The species nomenclature follows Czerepanov [25]. The tree height and inclination were estimated roughly in the field. Altitude, shrub or tree layer height were given in meters. Geographical coordinates and altitude were measured by Garmin GPSmap 60 CSx. As phenological aspects were considered in the fieldwork, basic investigations were conducted from June to July. Sporadically the woods were also checked in the autumn (October) to collect plants from the *Artemisia* genus for precise species determination. The syntaxonomic classification was done according to Hilbig [26], considering also Mirkin et al. [27] and Wehrden et al. [28].

For documentation of habitat conditions governing the occurrence of the community, alkalinity (with ELMETRON CP-105 pH meter) was determined for plots of the vegetation studied. In addition, the soil pits were dug out to find out the soil profile.

Results

Syntaxonomic position of the association

In Middle Asia the community of *Populetum talassicae* occurs in valleys of mountain rivers and along the shores of mountain lakes, in the zone of episodic or periodic flooding. Its syntaxonomic position is as follow:

Cl.: *Populetea laurifolio-suaveolentis* Hilbig 2000

O.: *Betulo-Populetalia talassicae* ord. nova (nomenclatural type hoc loco)

All.: *Populion talassicae* all. nova (nomenclatural type hoc loco)

Ass.: *Populetum talassicae* ass. nova (holotypus hoc loco, Tab. 1, rel. 3)

SubAss.: *Populetum talassicae caricetosum orbiculari* subass. nova (holotypus hoc loco, Tab. 1, rel. 17).

Floristic structure, ecology and habitat preferences of *Populetum talassicae*

In the phytocoenoses of *Populetum talassicae* community *Populus talassica* clearly predominates; it reaches a surface of cover from around 10 to 95%, with an average of around 60%. Only in a few cases was the complex of trees supplemented by an admixture of *Betula seravschanica*. Separate plots of this community are relatively diverse in terms of floristic richness.

Tab. 1 *Populetum talassicae* ass. nova in Middle Asia.

Successive number of relevé	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
day	17	17	18	8	8	17	17	17	18	18	18	18	19	18	17	5	19	18	
month	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	
year	2010	2010	2010	2009	2009	2010	2010	2010	2010	2010	2010	2010	2010	2010	2010	2009	2010	2010	
Altitude (a.s.l.)	2720	2750	2220	2207	2210	2650	2700	2720	2200	2200	2200	2220	2205	2200	2720	2220	2225	2200	
Cover of a layer (%)	80	79	60	55	60	50	65	75	20	5	70	65	55	60	65	50	80	75	
Cover of b layer (%)	10	10	5	5	5	35	40	20	60	50	15	60	15	30	5	2	15	30	
Cover of c layer (%)	60	80	50	75	80	60	70	65	35	50	75	50	20	45	90	65	100	70	
Cover of d layer (%)	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-	
Relevé area (m2)	300	300	400	400	400	300	400	400	300	300	400	400	400	400	400	400	400	400	
Inclination (%)	0	0	0	0	0	35	30	0	0	0	0	0	0	0	0	0	0	0	
Exposition	-	-	-	-	-	NW	NW	-	-	-	-	-	-	-	-	-	-	-	
Tree medium hight	25	25	21	15	16	16	19	20	18	17	22	21	17	18	20	15	19	19	
Soil pH	-	-	8.2	8.1	7.95	7.65	8.19	7.8	8.2	8.3	7.5	8.15	8	8.25	7.6	7.8	7.1	7.4	
Locality	KK	KK	LK	LK	LK	A	Sa	KK	LK2	LK2	LK2	LK	LK	LK2	KK	LS	LS	LK2	
Number of species	20	22	14	14	11	36	22	18	23	15	19	13	21	20	28	17	19	17	**Constancy**
Ch. Ass. *Populetum talassicae*																			
Populus talassica a	3	4	4	4	4	3	3	3	2	1	4	4	4	4	4	4	5	4	V
Populus talassica b			1	1	1	1	1					4	1	+		+	1		III
Sporadic species: *Populus talassica* a2 2(2), *Populus talassica* c 12																			
D. SubAss. *Populetum talassicae caricetosum orbiculari*																			
Dactylorhiza umbrosa															1	+	1	+	II
Carex orbicularis subsp. *hissaro-darvasica*															1	2	2		I
Ch. All. *Populion talassicae*																			
Astragalus tibetanus	1	2	3	3	3	2	+	+	1	1	1	1	+		+			2	V
Pedicularis dolichorhiza	+		3	2	1	+			2	2		+		+	1	+	1	1	IV
Ch. O. *Betulo-Populetalia talassicae*																			
Betula seravschanica a	3	2				1	1	1											II

Tab. 1 *(continued)*

Successive number of relevé	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Con.
Betula seravschanica a2	2	2																	I
Betula tianschanica b									2									1	I
Sporadic species: *Betula seravschanica* b 6(1)																			
D. Cl. *Populetea laurifolio-suaveolentis*																			
Poa pratensis	1	2	1	1	2	+		1		+	+	2	+	1		+	+	+	V
Vicia tenuifolia			+		+	1	1				1	2			+	+	+	1	III
Others																			
Taraxacum sp.	2	3	1	2			1	+		+	+	+	+		1				IV
Trifolium repens	2	3		+	1		+	2			+	1	+		1				III
Seseli schrenkianum						+	+	1	2	2	+			+	+				III
Hipophaë rhamnoides b				1	1	2						1	1	1		+		+	III
Lonicera stenantha b		1				+	1		1		2			1		+		+	III
Polygonatum roseum						2	1	r		+	1				+	+		1	III
Epipactis helleborine			+					+	+	+	+	+		+				+	III
Ligularia thompsonii	3	2	+			2	2	3							1				II
Salix linearifolia b		1							3		+		1	2			1	1	II
Poa nemoralis						1	+	1	1				+	1	+				III
Equisetum arvense						3		1			3					4	4	2	II
Poa bulbosa	2	2	1	2	2	1													II
Leptorhabdos parviflora						+	+		1	+	1	2							II
Ealeosticta allioides	+					+	+	1	+						+				II
Carum carvi		+	+				+	1							+		+		II
Geranium collinum			+				2					+				1	1		II
Lathyrus pratensis									1					1		1	+	+	II
Phragmites australis				+												+	1	3	II
Trifolium pratense	2			+	2										1				II
Euphrasia tatarica			+								+				2	+			II
Calamagrostis pseudophragmites									1	+			1					+	II
Erysimum alaicum						+						+	+	+					II
Juniperus seravschanica b	2	1					2												I
Juniperus semiglobosa b								2			1				1				I
Pedicularis olgae						+	+				2								I
Bromus tectorum		+											1	1					I
Equisetum ramosissimum						+									1		+		I
Medicago lupulina				+	+								+						I
Heracleum lehmannianum						+								+			+		I
Festuca sp.	2	2																	I
Veronica arguteserrata	2	2																	I
Juniperus seravschanica a2	2	1																	I
Astragalus kabadianus						1	2												I
Poa sp.	2	+																	I
Arenaria serpyllifolia	1	1																	I
Bryum sp.	1	1																	I
Berberis integerrima b						1		1											I
Gentianella turkestanorum							1								1				I
Draba nemorosa	1	+																	I
Galium spurium	1													+					I
Alchemilla hissarica	1														+				I
Trifolium seravschanicum			1													+			I
Galium boreale							1								+				I
Pyrola rotundifolia								1							+				I
Silene wallichiana						+				1									I
Astragalus sp.											+			1					I
Clematis orientalis													+	1					I
Lactuca tatarica		+				+													I
Potentilla asiae-mediae		+									+								I

Tab. 1 *(continued)*

Successive number of relevé	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Con.
Angelica ternata			+					+											I
Potentilla conferta				+	+														I
Picris nuristanica						+							+						I
Artemisia dracunculus									+	+									I
Lappula consanguinea									+					+					I
Neottia kamtschatea														+				+	I
Erigeron pseuderigeron						+								r					I
Conringia planisiliqua				r										+					I

Sporadic species: *Aegopodium tadzhikorum* 7, *Alyssum desertorum* 6, *Angelica komarovii* 17, *Artemisia persica* 13(1), *Astragalus nobilis* 9, *Bromus gracillimus* 9, *B. lanceolatus* 6, *Carex diluta* 16, *C. karoi* 15(1), *C. songarica* 17, *Chamaenerion angustifola* 10, *Chesneya biternata* 13, *Colutea paulseni* b 9(1), *Conringia persica* 6, *Cortusa turkestanica* 17, *Cotoneaster hissaricus* 13, *Dactylis glomerata* 12, *Descurainia sophia* 9, *Erigeron acris* 13, *Elymus multicaulis* 11, *Gentianopsis vvedensky* 15, *Geranium regelii* 17, *Heleocharis meridionalis* 15(3), *Hieracium regelianum* 6, *Ixiolirion tataricum* 4(r), *Juniperus turkestanica* c 6, *Lolium perenne* 13, *Medicago sativa* 6, *Mentha asiatica* 17(1), *Musci indet.* 16(1), *Onobrychis baldshuanica* 6, *Oxytropis capusii* 6, *Parnassia lehmanii* 15, *Phlomis canescens* 9, *Piptatherum kokanicum* 13, *Plantago lanceolata* 6, *Polygonum aviculare* 2, *Potentilla orientalis* 9, *Primula olgae* 15, *Rochelia cardiosepala* 6, *Rosa popovii* b 7(1), *R. popovii* c 9, *Salix capusii* b 10(1), *S. pycnostachya* b 10(3), *S. linearifolia* a2 16(1), *Schtschurovskia maeifolia* 6, *Swertia juzepczukii* 15, *Tragopogon conduplicatus* 9, *Triglochin palustre* 15(r), *Valerianella ovczinnikovii* 13.

A – Arch valley; Con. – constancy; KK – Kara-Kul valley; LK – Lake Iskanderkul; LK2 – SW shore of Lake Iskanderkul; LS – Lake Semirabadun; Sa – Sarytag.

In phytosociological relevés from 11 to 36 species, around 19 taxa, were noted. The total number of taxa noted in the plots of studied community reached 107 species (Tab. 1).

The layer of bushes reaches a coverage of between 5 and 60%, which consists primarily of willow species, *Salix* spp., as well as of *Hippophaë rhamnoides*, *Lonicera stenantha*, *Juniperus semiglobosa* and *J. seravschanica*. In the undergrowth, *Populus talassica* occurs relatively commonly, although in small quantities.

The forest herbal layer is richest in taxa. A high stability and the number of species associated with meadows and pastures are characteristic here, mainly *Poa pratensis*, *Vicia tenuifolia*, *Trifolium repens*, *Trifolium pratense*, *Carum carvi*, *Galium boreale* and *Lathyrus pratensis*. However, it is clearly marked with a share of taxa considered as characteristic of the *Populion talassicae* alliance, i.e. *Pedicularis dolichorhiza* and *Astragalus tibetanus*, and species distinguishing the class *Populetea laurifolio-suaveolentis*, i.e. *Poa pratensis* and *Vicia tenuifolia* (Tab. 1). In the humid subassociation, i.e. *P. t. caricetosum orbiculari*, a predominance of species such as *Equisetum arvense*, *Phragmites australis*, *Carex orbicularis* or *Dactylorhiza umbrosa* has been observed. The total cover by shrubs is relatively smaller in this subassociation (Tab. 1, Fig. 2).

Phytocoenoses of the noted *Populetum talassicae* community formed small surface-forest complexes in the estuary sections of streams to Lake Iskanderkul and Semirabadun as well as in the valleys of mountain streams, i.e. Karakul, Arkh and Iskanderdarya. In the valleys they occupy much smaller areas but are distinguished by a greater floristic richness. They develop not only in the valley floors, but also on the slopes adjacent to willow thickets and buckthorn (Fig. 2).

The *Populetum talassicae* community is a typical mountain forest community occurring at an altitude of 2200–2750 m above sea level. It develops mainly in the alpine landscape of the valley floors and mountain streams in the coastal zone of mountain lakes, an observation supported by the appearance of taxa, which have typically mountain distribution such as *Trifolium seravschanicum*, *Pedicularis olgae* or *Gentianopsis vvedensky*. The humus layer in soils is either very thin (10 cm) or completely absent (skeletal or residual soils). Only in the humid subassociation does the *Populus talassica* community grow on peat substrates with thicknesses up to 1 m (boggy soil; Fig. 3). In general, the community studied develops in areas of flood inundations and floods caused mainly by spring thaw. That led to, amongst other features, intensive deposition of pebbly material and this explains why in many sites the coverage of the herbal layer is very poor because of the accumulation of a thick gravel layer. In all cases, the soil environment has an alkaline reagent, sometimes over pH 8.

Distribution

The potential range of the distribution of the *Populetum talassicae* community is contained within the range of its base edificator, i.e. *Populus talassica* and is limited by the mountains of Middle Asia, such as Pamir-Alai and Tian-Shan. However due to intensive forest cuttings in last decades, in many places were formerly or at present *Populus talassica* does occur, the association of *Populetum talassicae* disappeared. On Tajik territory, communities of this species occur in a limited range, mainly in the Zeravshan Mountains at altitudes of around 1800 to near 2800 m. above sea level [29] (Fig. 4, Fig. 5). The community of *Populus talassica* has its own potential biotope in shore areas of large and small mountain lakes. Above 2800 m a.s.l., for example, in the valley of Pasruddarya near Lake Alaudinsk, this community does not form stands but only some loose coppices and small groups of trees appear there. In the river valleys of Zeravshan Mts, the *Populus talassica* community does not occur below 1800 m and potentially forms the belt zone of forest adjacent to the willow bushes and vegetation built by species that are able to resist strong currents of mountain edge locations of V-shaped valleys of mountain streams, often appearing also on the scarps of eroded river slopes. This is of course possible in a few sections of the rivers with a slightly wider valley and on not too steep slopes where there is access to shallow groundwater. Such habitat delimitation of the range of the studied group as

well as the nearest of main roads situated mostly at the bottom of river valleys explains why forests of this type in many localities were completely grubbed, which led to a significant reduction of the distribution area of this community. Those territories were converted to pastures, fields or human settlements. Meanwhile, now the herbal layer of these forests is relatively intensively used and often degraded by pasture of farm animals (sheep, goats, cows) or mowed in the second half of the year, in order to obtain hay (for example, near Lake Semirabadun).

In Tajikistan, remaining forests of talassica poplar is not more than 5% of the initial areal extent. Given the high threat to forest communities in Tajikistan [13,14] and increasingly smaller areas of forest in general in this part of Pamir-Alai, we may assume that the area of distribution of *Populetum talassicae*

Fig. 2 **a** *Populetum talassicae* along the southern shore of Lake Iskanderkul. **b** Panorama of the Nature Reserve of Lake Iskanderkul with two patches of *Populetum talassicae*. **c** Wet subassociation of *Populetum talassicae caricetosum orbiculari* with predominance of *Equisetum arvense*. **d** *Populus talassica*. **e** The shore edge of *Populus talassica* forest. **f** *Pedicularis dolichorhiza* – a diagnostic species for the *Populion talassicae*. **g** *Populetum talassicae* on gravel alluviums.

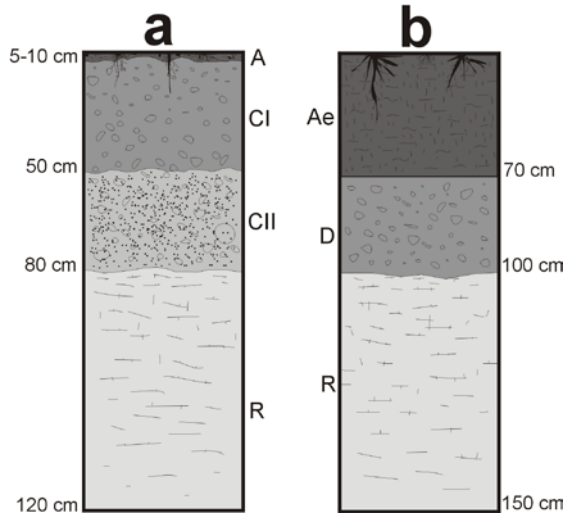

Fig. 3 Soil profiles of *Populetum talassicae*: typical (**a**), wet variant on peat soil (**b**). A – humic layer; CI – upper alluvial mineral layer; CII – lower alluvial mineral layer; D – diluvial layer; Oe – organic peat layer; R – bedrock.

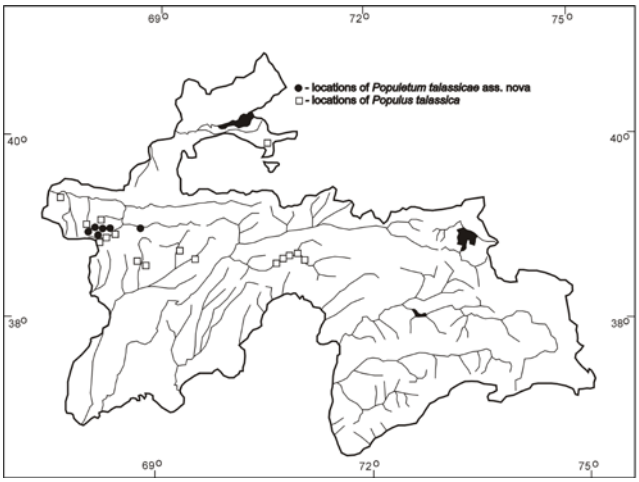

Fig. 4 The distribution of *Populetum talassicae* ass. nova and *Populus talassica* in Tajikistan.

Fig. 5 The potential range of *Populetum talassicae* ass. nova in Middle Asia.

will continue to decrease. Now it barely reaches 500 ha in total. Only in few locations are *Populetum talassicae* protected in nature reserves or included in the complex of guarded objects of recreational centers.

Discussion

Studies conducted on the territory of Tajikistan show that probably the main occurrence center of *Populetum talassicae* is the area around Lake Iskanderkul in the Funn Mountains. In zones of the estuaries of three mountain streams to the lake the largest areas of forest covering about 90% of the known area of this community in Tajikistan have developed. Despite the penetration of the field of river valleys in the eastern Zeravshan Mountains as well as in western Pamir and the Gissar Mountains (rivers Pyandz, Vanch, Shakhdara, Takob, Khondara, Sorbo, Sardai-Miena, Varzob, Surkhob and some smaller ones), plots of *Populetum talassicae* community have not been found. Another considerably large forest of *Populus talassica* is known from the neighbourhood of Talas in Kyrgyzstan, but, these phytocoenoses are presently significantly degraded by cattle grazing.

The community *Populetum talassicae* is included in the *Populetea laurifolio-suaveolentis* class because of habitat similarities, i.e. occupying the wings of river valleys, mostly mountainous (at least not in the broad low-lying valleys of great rivers), and floristic and structural congruencies – for example, a large share of meadow species in the undergrowth, the relatively low tree density and dynamics of phenological communities adapted to temperate and mountain climates [26]. A significant share of meadow plants is probably caused by the still persistent grazing and mowing of ground vegetation in Tajik forests. The community of *Populetum talassicae* is a geographical equivalent to a community with a predominance of *Populus laurifolia* described from central Tian-Shan as the association occupying habitats close to mountain rivers with stable contact to complexes of *Salix* sp., *Tamarix* sp. and *Myricaria* sp. [30].

Because in the Pamir-Alai area species diagnostic for *Populetea laurifolio-suaveolentis* class do not occur (e.g. *Populus laurifolia*, *P. suaveolens*, *Artemisia mongolica*, *Elymus sibiricus*, *Heracleum dissectum*, *Lactuca sibirica*, *Pedicularis resupinata*, *Thalictrum simplex* and *Vicia cracca*) [26], two permanent meadow species, namely *Poa pratensis* and *Vicia tenuifolia* were proposed as weakly distinctive for this class. They were previously identified as diagnostic taxa in such communities in Central Asia [27]. Further studies of riparian plant communities belonging to this class, first of all in the Tian-Shan area, are needed to revise this proposal.

Because of the absence of characteristic liana species for the class *Salicetea purpurae* and the absence of persistent flooding, the association of *Populetum talassicae* was not classified in this syntaxon, in spite of the fact that in the bush layer the participation of, for example, *Salix pycnostachya*, *S. capusii* and *S. linearifolia* was clearly noted. These species are much more widely distributed in adjacent shrub communities, where in addition to willows there is a significant share of species belonging to the genera *Tamarix* and *Myricaria*. Those bush plant communities show great habitat similarities to communities of alliance *Salicion eleagni* from the class *Salicetea purpurae* described from mountain stream valleys of the Alps and Carpathians [31–33].

The *Populetum talassicae* community also significantly differs from phytocoenoses of thugay forest. These are communities

growing in warmer and drier climates, which is reflected in the different floristic composition of undergrowth and seasonal dynamics of the species. It seems reasonable to include the thugay forest in the class *Populetea euphraticae* more often occurring in low-lying broad river valleys (e.g. Amu-Daria) and desert oases [26–28].

The establishment of a new order was necessary due to floristic differences and geographical distribution of shrub and forest communities azonally occurring along the rivers of Middle Asia. Most species making up the described communities from Middle Asia from the order *Populetalia laurifolio-suaveolentis* belong to a circumboreal element. Among the taxa present in the order presented here *Betulo-Populetalia* talassicae are frequent species with an Irano-Turanian distribution. As distinctive and characteristic for that order, taxa relatively often occurring along mountain rivers and composing so-called bielolesya – *Betula seravschanica* and *B. tianschanica*, were chosen (Tab. 1). Within the order, the alliance of *Populion talassicae* was singled out. This includes the poplar forest communities developing in the higher elevations of mountain rivers with swift current or in the estuary areas of mountain lakes. In addition to *Populus talassica*, communities of other poplar species, e.g. *Populus pamirica* or birches should probably also be included in this alliance. However, the confirmation of this hypothesis requires further phytosociological studies. Species proposed as characteristic for this alliance are *Pedicularis dolichorhiza* and *Astragalus tibetanus*. Both taxa achieve high constancy here. Phytosociological studies conducted in Tajikistan in other forest communities, for example, in the mesophilous deciduous forests, thugay as well as communities consisting of *Betula* spp. or *Salix* spp., have not confirmed the presence of these plants with great constancy and significant coverage. The described association of *Populetum talassicae* is marked by a clear predominance of *Populus talassica* as the main forest-building species composing the tree layer.

Unlike stream shrub communities, association of *Populetum talassicae* develops in locations with less dynamic processes of alluvial deposits, where the surface layer of humus in the soil profile is present. Only in the event of changes in the stream bed, or anthropogenic factors, exceptionally strong inundations, does the poplar forest floor consist of gravel, which reflects primarily depletion of forest ground flora (in phytosociological pictures taken at plots of this type of forest noted from 11 to 15 species). As a mountain community the association of *Populetum talassicae* is well adapted to periodic fluctuations in flow levels.

The poplar forest is a community of typical alpine landscape, which is reflected, among others, in the dynamic development during the growing season. Developing poplar leaves in May, towards the end of September, they lose leaves and the community, along with the first frost and snow, in October goes into winter dormancy. It is a unique forest community in terms of phenology, going through the entire developmental cycle in about 5–6 months.

The community of *Populetum talassicae* is a unique community of the highest formation of deciduous forests in Pamir-Alai. Higher, the harsh habitat conditions, in particular the very short growing season, exclude the development of broad-leaved forest communities. Therefore, the community is essential in the researches of an altitudinal range of communities, including the relations to climate change [34,35].

Actually, the largest patches of community built by *Populus talassica* are included in the protected nature reserve of Iskanderkul. This kind of legal preservation, as well as the location of the office of state conservation service and government institutions in the close vicinity of the forest, appears to be an effective form of conservation of the last plots of *Populetum talassicae* in Tajikistan.

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Authors' contributions

The following declarations about authors' contributions to the research have been made: project coordination, field research, data analyse, preparing the manuscript: AN; field research, preparing the manuscript: MN.

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