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Representation of Endemics in Floristic Subprovinces of Kazakhstan

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ABSTRACT

The aim of this review is to analyze the data published on Kazakhstan's endemic species in different botanical issues. In the Kazakhstan flora there are 775-710 endemic species (some of which are now defined as subendemics). The rate of endemism in the territory is relatively low and estimated at approximately 12% of total species. However, endemics are not evenly distributed throughout the country's territory. Kazakhstan's floristic subprovinces (botanical-geographic regionalization by Takhtadzhian 1978) have a significantly different amount of endemics; some of them include only 10-15 endemic species while others contribute up to 150 species, including endemic species growing in two or more floristic subprovinces. The number of endemics found in only the floristic subprovinces account for more than 60% of the total number of Karatau endemics, almost 50% in each Zailisky Alatau and Jungar Alatau, ~40% in Western Tien-Shan, and ~30% in Tarbagatai (all mountain zones), ~40% in Betpak Dala, and ~30% in each Balkhash-Alacol and Chu-Ili Mountains (desert zones). Although a considerable number of endemic species occur in the mountainous floristic subprovinces and their neighboring subprovinces, most endemic species inhabit dry, hot locations, even in the mountains on rocky dry steppes or deserted slopes, conical shaped hills and piedmonts. The current safety of Kazakhstan endemics is discussed in relation to habitat destruction.

Keywords: endangered groups, endemism, regional biodiversity, spatial distribution, taxonomic groups

INTRODUCTION

Kazakhstan is situated in the centre of Euroasia. The main part of its territory is included in the Iran-Turan floristic region, a part of the Tethyan (Ancient Mediterranean) Subkingdom (Takhtadzhian 1978). According to Takhtadzhian, the world land division for floristic areas is based substantially on taxonomic, ecological and archeological diversity of plant species caused by climatic conditions, geology, soil, orography (the physical geography of mountains and mountain ranges), etc. The complicated picture of a contemporary flora is the result of the action of three main factors: evolution, migration and extinction (Kamelin 1990). The vegetation of the Mediterranean Basin is a result of the long gradual drying process of the ancient Tethyan Sea while drawing together the northern meadow-forests and the southern arid vegetation (Popov 1983). Kazakhstan is situated between 40-55°N latitude and 46-87°E longitude. Vast in size, the land in Kazakhstan is very diverse in terrain types: forests in the north, flatlands, steppes, deserts, deltas, rock-canyons, hills, in part snow-capped mountains; nevertheless, the territory is mainly covered by steppes and deserts. Drought-resistant plants are spread-out in the central Kazakhstan steppe up to the Tien-Shan mountain system. Desert vegetation cover changes from the north to the south and is subdivided into 3 subzone types: northern, middle and southern deserts, and piedmont desert type (Rachkovskaya *et al.* 2003). The existence of piedmont desert is caused by a piedmont-humid effect of the mountains. The Altai Mountains, compared to Tien-Shan, are characterized by typical Siberian flora found nowhere else in Central Asia. Moreover, Weber (2003) revealed an extraordinary similarity of the Russian Altai flora to that of the American Southern Rocky Mountains. Thus, endemism in Kazakhstan flora indicates its local development in the confluence of northern and southern lowland and mountain landscapes formation during its long and complicated geological history. Academician NA Vavilov (1987) considered Central Asia as a region with biodiversity of global importance. This is especially true for its plant biodiversity as an important center of ancestral forms (with unique gene pools) of many cultivated plants.

In Kazakhstan more than 6000 species of world flora are represented. Of these, approximately 2000 plant species inhabit semi-desert and desert areas while about 2500 are in vast steppe semi-arid grassy plains. In the east, southeast, and south there are mountains (about 7%) with more than 2500 species. A brief description of Kazakhstan flora biodiversity has been presented elsewhere (Ryabushkina *et al.* 2008). Endemic species represent approximately 12% of total vascular species. Kazakhstan floristic subprovinces have significantly different amounts of endemics. Among the top plant families in Kazakhstan the percentage of endemic species varies greatly, from approximately 30% in each of the Alliaceae and Liliaceae families, 20% in the Fabaceae, 16-17% in each of the Boraginaceae, Lamiaceae, Asteraceae, to 4% in the Poaceae, 2% in the Cyperaceae, etc. A representative description of endemics, in particular families and distribution through Kazakhstan floristic subprovinces, is given next.

GENERAL PECULIARITIES OF KAZAKHSTAN FLORA

Many eminent soviet botanists have contributed much to the investigation of Kazakhstan's flora. Floristic comparative analysis is based on the principle of "incomplete" flora of any natural region of the world (Kamelin 1990). For any floristic region a characteristic composition of plant families with more or less stable quantitative relations among

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Table 1 The amount of endemic species in some individual plant families and genera in Kazakhstan (by Baitenov 2001).

Family	Number of genera/endemic genera/% in the region	Species number in the region	% Species to the number in the world family	Endemic species in the region	Endemics, % to the family spp.
Alliaceae J. Agardh	1	140	20	31/ 45/ 5	32
Apiaceae Lindl.	79/17/22	232	8	56/ 35/ 19	15
Asphodelaceae Juss.	1	15	1	2/ 2	13
Asteraceae Dumort.	146/35/24	883	4	136/ 138/ 32	16
Berberidaceae Juss.	4	13	2	2/ 2/ 2	15
Boraginaceae Juss.	44/9/20	161	6	30/ 28/ 7	17
Brassicaceae Burnett	96/31/32	330	11	47/ 43/ 12	13
Caryophyllaceae Juss.	42/3/7	282	14	20/ 20/ 6	7
Chenopodiaceae Vent.	51/25/49	256	17	22/ 20/ 3	8
Cyperaceae Juss.	19/	182	5	3/ 3	2
Euphorbiaceae Juss.	4	69	1	8/ 7/ 1	11
Fabaceae Lidl.	45/3/7	671	4	148/ 147/ 22	22
Iridaceae Juss.	5	36	2	5/ 4/ 4	11
Lamiaceae Lindl	49/11/22	247	7	50/ 40/ 7	16
Liliaceae Juss.	8	83	7	18/ 24/ 11	29
Limoniaceae Lincz.	7	52	9	11/ 16/ 6	31
Poaceae Barnhart	101/1	482	5	36/ 21/ 4	4
Polygonaceae Juss.	11	141	17	56/ 14/ 3	10
Ranunculaceae Juss.	33	208	10	9/ 11/ 3	5
Rosaceae Juss.	34	212	7	19/ 22/ 5	10
Rubiaceae Juss.	8	61	1	5/ 4/ 2	7
Scrophulariaceae Juss.	24	176	6	27/ 24/ 7	14
Tamaricaceae Link	4	21	23	-	-
Zygophyllaceae R.Br.	2	31		13/ 4/ 1	13
Total 161 (**B**)	1118 (**B**)	6040 (**B**)	(**KF/B**)	775/709/173 **KF/B/RB**	(**B**)

KF – Kazakhstan Flora 1956-1966; B – Baitenov 2001; RB – Red Data Book of Kazakh SSR 1981

them is typical (Tolmachev 1974). For preparing this publication the results of those long-standing works were analyzed, including: Kazakhstan Flora (Vols 1-1X, Pavlov 1956-1966, 1959; Key Book of Middle Asia Plants (Vols 1-X, Kovalevskaja *et al*. 1968-1993; Goloskokov 1969, 1984; Tolmachev 1974a; Baitenov 1982, 2001; Kamelin 1990; Aralbaev 1997; Abdulina 1999; Rachkovskaya *et al.* 2003).

According to Baitenov (2001) the flora in Kazakhstan comprises 161 families, 1118 genera and 6040 species; some of these data are shown in **Table 1** (families enumerated alphabetically). Analysis of the flora shows that the top 15 plant families include about 80% of Kazakhstan vascular plant species. In that number Asteraceae Dumort. (~15%), Fabaceae Lidl. (~11%), Poaceae Barnhart (~8%), Brassicaceae Burnett and Caryophyllaceae Juss. (~5% each), Chenopodiaceae Vent., Lamiaceae Lindl, and Apiaceae Lindl (~4% each), Rosaceae Juss., Ranunculaceae Juss. (~3.5% each), Scrophulariaceae Juss., Cyperaceae Juss. (~3% each) Boraginaceae Juss., Polygonaceae Juss., Alliaceae J. Agardh (~2.5% each) (see Ryabushkina *et al*. 2008 for details).

The territory of Kazakhstan has been divided into 29 main floristic areas (subprovinces) and some sub areas (on **Fig. 1** marked by figures and figures with letters, correspondingly, from Pavlov. *Kazakhstan Flora.* 1956, Vol 1, p 35). The reader should always remember that, according to Takhtadzhian (1978), any floristic division is partly conditional, "caused by a some simplification of real floristic relations".

REPRESENTATION OF ENDEMICS IN FLORISTIC SUBPROVINCES OF KAZAKHSTAN

Species are the most prominent and readily recognizable form of biodiversity (Kamelin 1990). At the same time, botanists consider endemics and endemic taxa as the best criteria for any floristic territory. Endemism richness can be interpreted as the specific contribution of an area to global biodiversity (Kier and Barthlott 2001). Endemism is the principal criterion for *hotspot* status determination because endemic species are entirely dependent on a single area for their survival, and by virtue of their more restricted ranges, are often the most vulnerable (Myers 1988). An indicator for floral dynamism is endemism availability in certain groups and the absence of endemism in others. Soviet botanists have suggested defining the endemism of territories not as a percentage of endemics, but as an endemism index, which also accounts for the number of all species and the size of a habitat's territory (Bikov 1979). Using the formula offered by Bikov, it would make a comparison of an area's endemism more reliable. However, as sufficient data for the exact number of species and area in km^2 for most Kazakhstan floristic subprovinces have not been estimated, we could not calculate the endemism index for any Kazakhstan floristic area. Moreover, it is difficult to determine the real area (km^2) in the mountains taking into account a complicated relief. Endemism may be expressed in percentage of all known taxa (excluding exotics), or as the absolute number of endemics in the area (Behera *et al.* 2002).

In the Iran-Turan region, Takhtadzhian (1978, pp 121-126) enumerates about 75 endemic genera in the Brassicaceae, about 70 in the Apiaceae, about 65 in the Asteraceae, about 30 in the Chenopodiaceae, 20 in the Lamiaceae, 15 in the Boraginaceae, and more than 10 in each of the Fabaceae, Caryophyllaceae and Poaceae families. In the Kazakhstan territory of all Irano-Turanian endemic genera there were representatives of 25 genera of the Chenopodiaceae (more than 80% of Iran-Turan endemic genera), 9 of Boraginaceae (~60%), 35 of the Asteraceae (~55%), 11 of the Lamiaceae (~55%), 30 of the Brassicaceae (~40%), 3 each of the Fabaceae, and Caryophyllaceae (~30%), and 17 of the Apiaceae (~25%). Among them there are numerous oligo- or even monotypic genera estimated to be endemic in the Kazakhstan flora (see Baitenov 2001). Up to 13% of plant species according to Pavlov (*Kazakhstan Flora*, Vols 1-1X, 1956-1966) and up to 12% of species described by Baitenov (2001) were considered as endemics in the Kazakhstan territory. A comprehensive inventory of 161 plant families described revealed 24 families, which include nearly all of Kazakhstan' endemics (see **Table 1**; the families with 1-2 endemics were excluded). Of all inventoried genera in the Kazakhstan territory about 50% of the Chenopodiaceae genera, more than 30% of the Brassicaceae, ~25% of the Asteraceae, and ~20% of each of the Apiaceae, Boraginaceae and Lamiaceae were described as endemic genera in

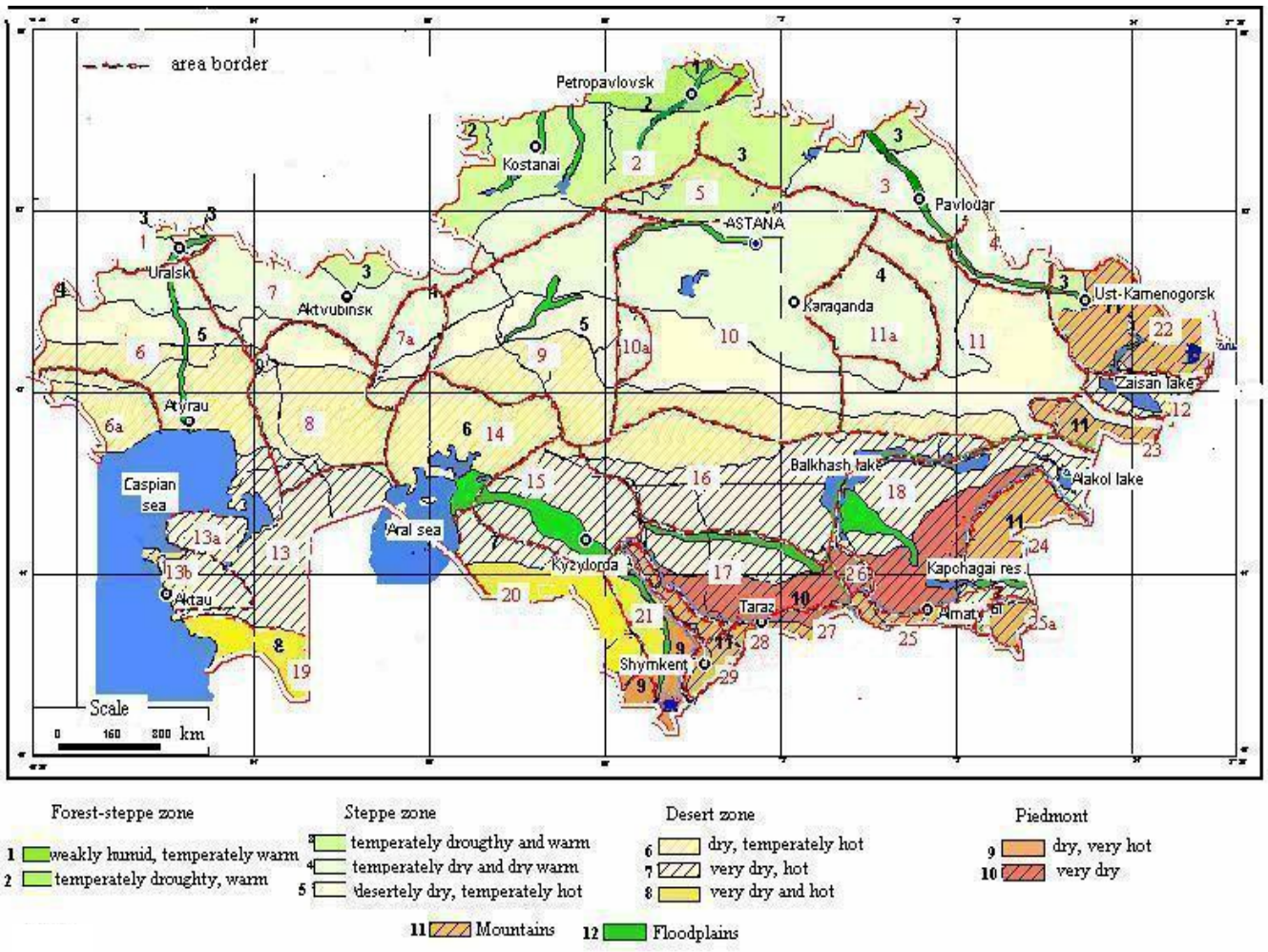

Fig. 1 Map of Floristic Areas (Subprovinces) and Nature Climate Zones of Kazakhstan. The map was a combination of the Kazakhstan map of floristic areas (Kazakhstan Flora. Ed. Pavlov. N.V. Academy of Sciences of Kazakhstan Republic, 1956) and the map of Nature climate zones and subzones, the Institute of Ecology and Stability of Development, 1998).

Kazakhstan. About one third of species of each of the Alliaceae, Limoniaceae and Liliaceae, one fifth of the species of the Fabaceae, and at least one sixth of species of the Boraginaceae, Lamiaceae, Asteraceae, and Apiaceae were marked as endemics. One can see in **Table 1** the differences in endemic number of some families from "*Kazakhstan Flora*" and Baitenov (2001). This may firstly be explained by sub-endemism revealed for some species determined previously as endemics. In **Table 1** there are also a number of endemic species included in "*The Red Data Book of Kazakh SSR*" (RDBK; Bikov 1981). The discussion of endemism in the Kazakhstan flora has taken into account possible changes in flora as a result of human activity and climate change.

We used the data from the "*Kazakhstan Flora*" in **Table 2** to reflect on the distribution of endemics throughout the Kazakhstan floristic areas because of the indicated locations of every endemic species in this issue. In Kazakhstan one fifth of 700 species of the world's Alliaceae family is described (**Table 1**). Vavilov (1987) considered the territory of Middle Asia (stretching from the Caspian Sea up to the Chinese Jungaria and from the Southern Usturt and Southern Aral region up to Northern Iran and Afganistan) as the center of origin of cultivated *Allium sepa* L. and *A. sativum* L. These species are closely related to local wild species *A. pscemense* B. Fedtsch., *A. obliquum* L., and *A. altaicum* Pall. The majority of *Allium* endemics in Kazakhstan inhabit the mountain floristic areas (**Table 2**) and many of them grow on rocky dry stepped or deserted slopes, conical shaped hills, and piedmonts.

Although only 15% of the Apiaceae family species (35-40) were described as endemics in the Kazakhstan territory, one should remember that they represent one fifth of the Irano-Turanian endemic genera including just a few or even one species, inhabitants of Pamir-Alai, Tien-Shan, the western and Middle Asia as well. Endemics of this family are spread-out in Semipalatinsky and Melkosopochnik floristic subprovinces (steppe zone), through the Balkhash-Alacol lakes' region and Moiyn Kum sands (desert zone) as well as in mountainous zones, including Tarbagatai, Jungar and Zailisky Alatau, further to Western Tien-Shan and Karatau. Most of them grow on sand, deserted salty plains, conical shaped hills, and rocky slopes.

About 140 species of the world's biggest family, the Asteraceae, were described as endemics in the Kazakhstan territory. In the region there are representatives of many genera growing mainly in the Iran-Turan region, particularly in western and Middle Asia, Pamir-Alai, and Tien-Shan. Species of half of Iran-Turan's endemic genera inhabit the Kazakhstan region. Endemics of this family were revealed in all floristic areas of Kazakhstan. There are territories with an increasing number of endemics: the steppe zone from Eastern Melkosopochnik to Ulutau, in the Balkhash-Alacol region and Moiyn Kum sands in the desert zone, with numerous numbers in mountain zones, Tarbagatai and especially in Western Tian-Shan, Zailisky Alatau with a maximum in Jungar Alatau and Karatau.

More than 17% of Boraginaceae family species were described in Kazakhstan as endemics, while representatives of 60% of Iran-Turan endemic genera grow in the territory. According to Kamelin (1990) a considerable number of Boraginaceae and Chenopodiaceae (see below) representatives typify the steppe and desert flora of Middle Asia. The area with the greatest quantity of endemics is Jungar Alatau

with a decreasing number in adjoining Tarbagatai, Balkhash-Alacol lakes region, Altai and Eastern Melkosopochnik. Endemic species grow on rocky slopes, rock cracks, deserted steppes, pebbles-sandy shallows. More than one tenth of the Brassicaceae family's world species have been inventoried in Kazakhstan. Among them there are many representatives of oligo- or even monotypic genera, while about 13% species are endemics. Representatives of 40% of Iran-Turan's endemic Brassicaceae genera were inventoried in Kazakhstan. A maximum number of family endemics were found in Zailisky Alatau with a decreasing number in the areas of the Betpak Dala desert, Chu-Ili mountains, Jungar Alatau and Tarbagatai. Another center of Brassicaceae endemism is Karatau with a decreasing number of endemics in neighboring Western Tien-Shan. There are also Brassicaceae endemics in Melkosopochnik. Endemic species inhabit rocky slopes, and sandy, clayey-salty soils.

The Caryophylaceae endemics are spread-out more or less uniformly in Kazakhstan floristic areas with slightly higher numbers in Karatau. The Caryophylaceae endemics account for about 7% in Kazakhstan, although there are 25% of Iran-Turan endemic genera in the territory as well. The Chenopodiaceae family representatives dominate the ecosystems of Asia and northern Africa with 30 endemic genera numbering in the Iran-Turan region. More than 250 family species were estimated to exist in Kazakhstan. There are many representatives with Crassulacean acid metabolism (CAM) and C_4 photosynthesis, some of the latter group even with no Kranz-type of leaf anatomy (Edwards *et al.* 2004). About 27% of Chenopodiaceae representatives grow in Kazakhstan sandy desert, 20 species were described as endemics. In the Kazakhstan territory more than 80% of the Iran-Turan endemic genera represent Chenopodiaceae. Endemics were found in all the desert climate zones and deserted dry steppes, but not in the northern-east floristic areas. They grow on sandy, salty soils, salt marshes, and broken rock slopes. More than 20% of the vast Fabaceae family representatives (about 150 spp.) were recorded as Kazakhstan endemics. Fabaceae endemics grow in all floristic areas. The maximum number of endemics was found in Jungar, Zailisky Alatau and Karatau mountains, fewer in the areas of Tarbagatai and Balkhash-Alacol lakes neighboring Jungar Alatau, and the Western Tien-Shan neighboring Karatau. The Lamiaceae family species are spread-out widely in the Mediterranean Basin, and in western and Middle Asia. As a result more than 25% of Irano-Turanian endemic genera were inventoried in Kazakhstan, with 16% (40 species) of endemics estimated to be Kazakhstan family representatives. The maximum number of endemics is in Karatau and Jungar Alatau and in the neighboring Balkhash-Alacol region. There are a number of endemics in Melkosopochnik. Of the 83 Liliaceae family species, 25% in Kazakhstan are inventoried as endemic. Liliaceae endemics were noted in the south, south-east and east floristic areas; the number of endemic species are found, in descending order, in Zailisky, Ketmen-Terskei Alatau, Chu-Ili

Table 2 Distribution of endemics of different plant families in Kazakhstan floristic areas.

Floristic area	# of floristic areas	Alliaceae	Apiaceae	Asteraceae	Berberidaceae	Betulaceae	Boraginaceae	Brassicaceae	Caprifoliaceae	Caryophyllaceae	Chenopodiaceae	Cyperaceae	Euphorbiaceae	Fabaceae
Spurs of general Sirt	1			4						1				1
Tobol-Ishym region	2			2			1	1						4
Irtyshsky	3			5/ 2			1	2/1						3
Semipalatinsky	4		3	3			1	1						3
Kokshetausky	5			2			1	2/1						4
Nothern Caspian region	6			6				1		2				3/ 1
Boukeevsky	6a			4						2				1
Aktyubinsky	7			4						2				2
Mougodzary	7a			6/1			1/1	1/1		2	1			6/ 2
Embainsky	8			4						1				1
Tourgaisky	9			4			1							4
Western Melkosopochnik	10		2	11/ 1		1	3/1	3		1	1		1	10
Ulutau	10a		2	11/2		1	2	2		1	2/1		1	10
Eastern Melkosopochnik	11		3/ 1	11/ 1		1	4/1	2		1	1		1	12/ 1
Karkaralinsky	11a		1	8/1		1	3	2		1	1		1	8
Zaisan	12	1/1	4/1	3			1	2				1	1	5/ 2
Nothern Ustyurt	13			5						1	1/1			1
Byzachi penninsula	13a			5						1	1			1
Mangyshlak penninsula	13б			5						1	1			1
Nothern Aral region	14	1/1		5/ 1			1			1	5/2		1	6
Kyzylorda region	15	1	1	5							2			2
Betpak Dala	16	3/1	5/4	7			4/2	6/ 5		2	2/1			6/ 1
Moiyn Kum sands	17		2/ 1	10						2	1		1	4/1
Balkhash-Alacol lakes reg.	18	1/1	5/2	11/2	1		5/3	5/3	1/1	3	5/3	1/1	3/1	12/ 3
Southern Ustyrt Plateau	19			5										
Kysyl Kum sands	20		2/ 1	6/ 1						1			1	
Turkestansky	21		1	5			1/ 1							
Altai	22		3	5/ 2			3/ 2	3		2/2		1	2/1	8/ 3
Tarbagatai	23	3	7/2	10/ 2			5/ 3	5/1				1		13/4
Jungar Alatau	24	4	11/6	30/ 12	1		7/ 6	5/ 2		3/2		1	1	33/ 20
Zaylyisky Alatau	25	9/4	7/ 4	25/ 7	1/ 1	1/1	2/1	12/ 7		2/ 1	1		3/ 2	32/ 17
Ketmen-Terskei Alatau	25a	2	2	13/ 5	1	1/1		4/ 1		1			1	8/2
Chu-Ili mountains	26	8/2	3/1	8/1				5/1		3/ 2	3/2		1	8/4
Kirghizsky range	27	1	4/1	12/2							1		1	6/ 2
Karatau	28	10/4	13/8	33/ 22			3/2	10/ 6	1/1	3/2	2		1	30/ 22
Western Tien-Shan	29	7/2	7/4	17/ 8		1/1	1	5/2		1	2		1	13/ 7

Values represented by a ratio: total amount of endemics in the area/amount of endemics characteristic only for this area
a =subarea

Table 2 (Cont.)

Floristic area	Iridaceae	Lamiaceae	Liliaceae	Limoniaceae	Orobanchaceae	Poaceae	Polygonaceae	Primulaceae	Ranunculaceae	Rosaceae	Rubiaceae	Rutaceae	Scrophulariacea	Thymelaeaceae	Zygophyllaceae
Spurs of general Sirt		1									1		1		
Tobol-Ishym region		1				2									
Irtyshsky		1				1				1/1					
Semipalatinsky		1				1									
Kokshetausky		1				2									
Nothern Caspian region		1				2					1		1		
Boukeevsky		1				2					1		1		
Aktyubinsky		1				2					1		1		
Mougodzary		1				2				1	1		1		
Embainsky		1				2							3/2		
Tourgaisky		1				2									
Western Melkosopochnik	1	4				1	2		1			1	4		3
Ulutau	1	5				1	2		1			1	4		3
Eastern Melkosopochnik	1	4/1				1	2		1			1	4		3
Karkaralinsky	1	6				2	2		1			1	4		3
Zaisan		4/1				2/1	30/ 28				1/1		1/1		
Nothern Ustyurt		1					3/3				1		2/1		
Byzachi penninsula		1									1		1		
Mangyshlak penninsula		1				1					1		1		1
Nothern Aral region			1			3	5/ 2				1	1			
Kyzylorda region		2	3			1/1	2								
Betpak Dala		2/1	1	1		2/2				2/ 1	2	1			2/2
Moiyn Kum sands		4	4/1	1			2			1	1		1		4/1
Balkhash-Alacol lakes reg.		8/4	4/1	1			9/4			1	2	1	2/1	2/2	5/1
Southern Ustyrt Plateau		1									1		1		
Kysyl Kum sands		3	3		1/1		9/ 4								
Turkestansky		2	3				1								
Altai	2/1	2/1	1	1		3/1			2/ 1	3	1/ 1		1/1	1	
Tarbagatai		4/1	1	3/2		2			1/ 1	3	1		1/1	2/1	
Jungar Alatau	1	9/3	5/ 1	1		4/ 4	2		3/2	7/2	1/1	1/1	7/4	1/1	2/1
Zaylyisky Alatau	3/ 2	4	10/ 4	2		13/ 11	3/1	1	2/2	8/4			4/1		1
Ketmen-Terskei Alatau	1	1	6	2		1		1		2	1	1/1	4		
Chu-Ili mountains	1	3/2	6/1	1/1		1	2			1			2/ 1		
Kirghizsky range	1	1	6			1	2	1		1			4		
Karatau		16/8	4/1	5/4	1/1	4/3	2		2/1		3/2	1/1	3/1		1/1
Western Tien-Shan		8/2	3			3/2	2	1	1	1/1	2		5/3		1

mountains and Jungar Alatau. Endemics are representatives of two genera: ephemeroids *Tulipa* L. and *Gagea* Salisb (Ivashenko 2005). Most of the Limoniaceae species are spread-out in the Mediterranean Basin, and in Western and Middle Asia in arid areas with high temperature, very low air humidity and, frequently, on salty soils. Some species have settled in places with high concentrations of heavy metals or oil-polluted soils. More than 30% of Limoniaceae species in Kazakhstan were inventoried as endemics growing in the south, south-east and east floristic areas.

In Kazakhstan about 40% of the Polygonaceae family species inhabit deserts, being representatives of the *Atraphaxis* genus and polymorphic *Calligonum* genus with C_4 physiology and photosynthesizing function transferred to stems. One tenth of family species are endemic, half of them growing in deserts. A considerable number of Polygonaceae endemics are found in very dry, hot deserts of Kysyl Kum sands and the Balkhash-Alacol lakes region. Numerous Calligonum endemics were found in the Zaisan floristic area, but there were many "controversial" endemics obviously due to morphological polymorphism (see Kourochkina 1978, p 43). In Kazakhstan, endemics account for ~14% of the Scrophulariaceae family with a maximum in Jungar Alatau, 13% of Zygophillaceae with a maximum in Moiyn Kum sands and Balkhash-Alacol areas, and ~10% of Rosaceae, most of them growing in the mountain areas of Zailisky and Jungar Alatau; these have been described in "*Kazakhstan Flora*".

Thus, the relative distribution of each family's endemics varies from area to area in the Kazakhstan territory. A considerable number of Alliaceae endemics was found in Karatau and Zailyisky Alatau, fewer in the Chu-Ili mountains and Western Tien-Shan (see semi-quantitative representation on **Fig. 2A**). Most Apiaceae endemic species are found in Karatau, and fewer in Jungar Alatau, Western Tien-Shan and Zailyisky Alatau (**Fig. 2B**). Most Asteraceae endemics are in Karatau, Jungar Alatau, and fewer in Zailisky Alatau and in Western Tien-Shan (**Fig. 2C**); Brassicaceae endemic spp. are found in Zailisky, and many in Karatau (**Fig. 2D**); Fabaceae in Jungar, Zailisky Alatau, Karatau (**Fig. 2E**); Lamiaceae in Karatau, Jungar, Balkhash-Alacol areas (**Fig. 2F**); Liliaceae in Zailisky Alatau, with fewer in the neighboring Chu-Ili mountains and Ketmen-Terskei Alatau (**Fig. 2G**); Polygonaceae in Zaisan, Balkhash-Alacol, Kysyl Kum (**Fig. 2H**). Most Poaceae endemics are in Zailisky; Schrophulariaceae in Jungar, Western Tien-Shan and Kazakh Melkosopochnik; Zygophyllaceae in Moiyn Kum and Balkhash-Alacol areas (not shown in **Fig. 2**). Maximum number of Boraginaceae endemics are in Jungar Alatau; Chenopodiaceae in the Balkhash-Alacol area and in the Northern Aral region.

In view of "double counting" which occurred for many endemics because there were numerous endemics growing in two or more floristic areas, about 20% of Kazakhstan endemics were described in each Karatau, Jungar, Zailyisky Alatau, ~12% in each Balkhash-Alakol and Western Tian-

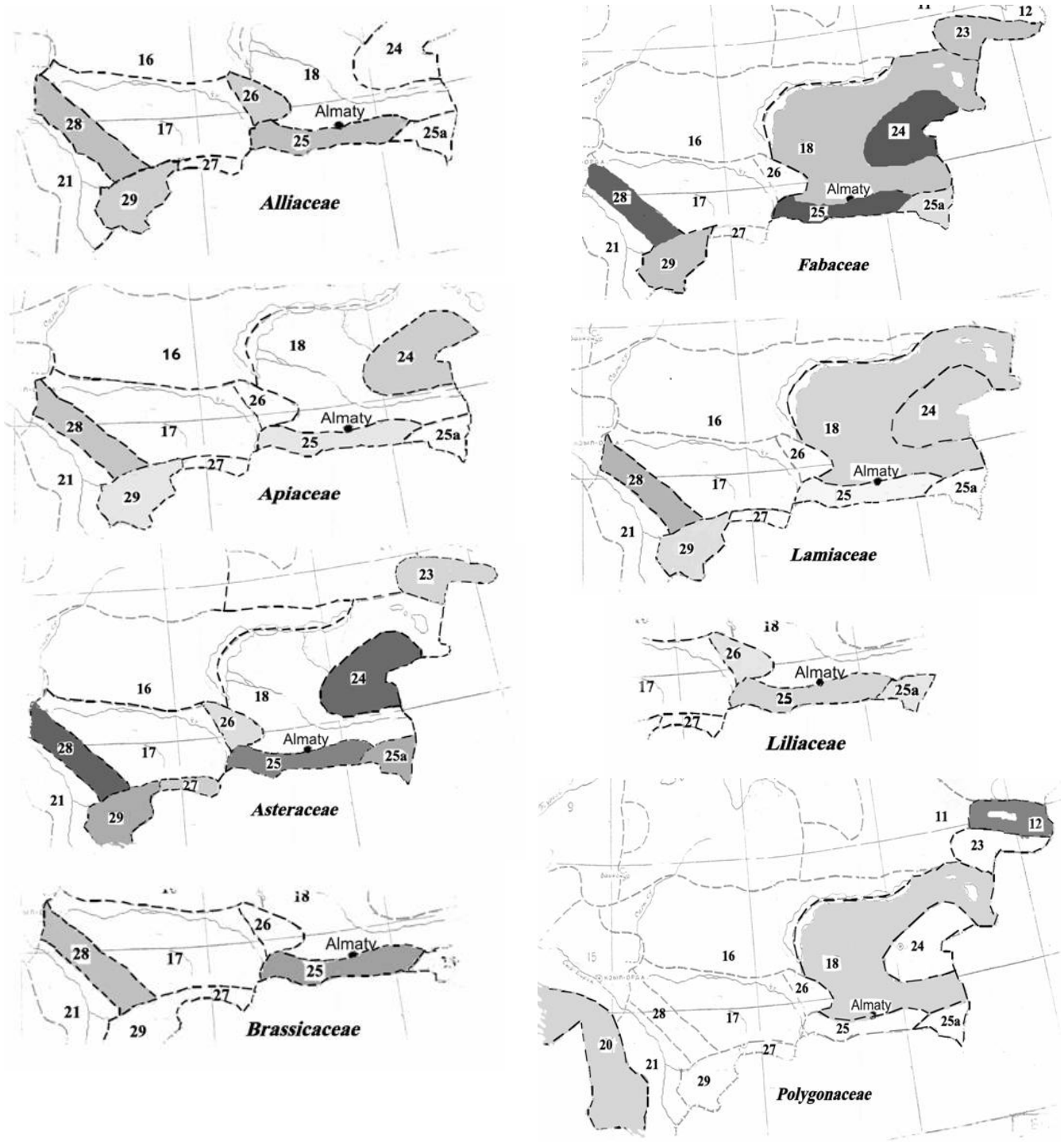

Fig. 2 Kazakhstan floristic areas with maximal amount of corresponding endemic families. Semi-quantitative scale from 1 to 35, each step of the scale is equivalent to 3 spp.

Shan, ~ 9 of endemics were found in Tarbagatai and Chu-Ili mountains, and ~ 7% in Ketmen-Terskei Alatau, Betpak Dala, and Kazakh Melkosopochnik. Thus, there are areas in the Kazakhstan territory with a high number of endemics, located in the south, south-east and eastern part of Kazakhstan, namely in Karatau, Western Tien-Shan, Zailisky and Jungar Alatau mountains. Obviously this is in agreement with the claim by Kőrner (2002) who stated that globally, mountain systems are hotspots of biodiversity and endemism owing to the compression of climatic zones over an elevational gradient. There are areas in Kazakhstan with comparatively high endemism, including the Chu-Ili mountains, Balkhash-Alacol lakes' subprovince, but the latter has a much greater area than the mountain areas. We selected specific endemics described only in the each certain area. The number of such species was more than 60% of all Karatau endemics; almost 50% in each Zailisky Alatau and Jungar Alatau, about 40% in Western Tien-Shan, and about 30% in Balkhash-Alacol, Chu-Ili Mountains and Tarbagatai (see semi-quantitative representation in **Fig. 3**). A very high percentage of endemics was described in the "*Kazakhstan Flora*" for the Zaisan floristic area, due to high polymorphism of the *Calligonum* genus (see Kourochkina 1978).

As we could find little data concerning the current state of Kazakhstan endemics we tried to involve analysis of the corresponding data of RDBK published in 1981 (Bikov 1981). In that edition more than 170 endemics (of 775 in the "*Kazakhstan Flora*", see **Table 1**) had been included. Among those, 5 were rare Aliaceae representatives; 19 were Apiaceae, and each of 15 of those was found and described only in one subprovince, only 4 were described in nature reserves, national parks or "zakazniks" (places, where

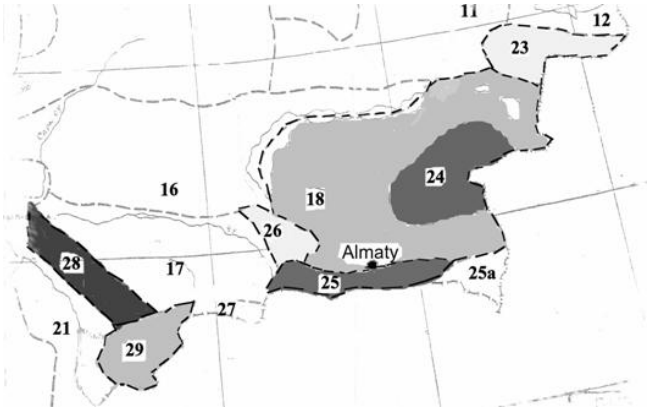

Fig. 3 Amount of endemics found in the only floristic area. Semi-quantitative scale from 5 to 95, each step = 5 spp.

certain kinds of economic activities are forbidden), correspondingly 19/15/4. Of 31 Asteraceae representatives 21 species were found only in one subprovince and only 4 in nature reserves, corresponding to 31/21/4; Boraginaceae 7/6/1; Brassicaceae 10/4/1; Caryophyllaceae 6/3/0; Chenopodiaceae 3/1/; Fabaceae 22/18/4; Lamiaceae 7/4/0; Liliaceae 9/5/2; Iridaceae 4/3/1; Limoniaceae 6/6/0; Poaceae 3/2/0; Polygonaceae 3/2/1; Rosaceae 5/2/1; Scrophulariaceae 7/7/1. Of 93 endemics grown only in Karatau, of 69 in Zailyisky and of 68 in Dzungar Alatau only 25 species from each floristic area had been included in RDBK. Ten endemic species have been found and described for all period of botanical observations only once. In general 105 species were found only in one floristic subprovince, 36 of them were described only in a few locations, with small ranges and small population size. Not less than 25 endemics were described in zones of the subsequent extensive pasture farming, which accelerated the degradation of vegetation and soil. Thus, only 20 species included in RDBK (173) grew in reserved territories.

DISCUSSION

Habitat destruction is the leading cause of species extinction (Pimm and Raven 2000). The most biodiverse regions of each continent are also the most threatened by the growth rate of human populations (Cincotta *et al.* 2000; Luck *et al.* 2004). Human settlement patterns impact biodiversity directly (e.g., habitat alteration) and indirectly by influencing land prices and other costs of achieving conservation (Luck *et al.* 2004). The main impact is an agricultural development that increasingly threatens global biodiversity (Gorenflo and Brandon 2005). The rate of habitat conversion is significantly higher in lands with adequate supplies of water than in areas less suitable for agriculture (Loehle and Li 1996; Seabloom *et al.* 2002). Empirical evidence suggests that intensification of agriculture rarely results in saving 'land for nature' (see Scherr and McNeely 2008). So far, as humans have clear preferences for certain habitats, it is likely that human activity is often spatially aggregated (Cohen and Smal 1998). Humans' actions fragment habitats via conversion of native ecosystems to agricultural lands, urban or suburban lands, roads, power line rights-of-way, etc. Fragmentation of the landscape breaks formerly contiguous wild species populations into smaller units that are more vulnerable to extirpation (Scherr and McNeely 2008). Habitat destruction can cause immediate extinction of those species that lived only in destroyed areas (Tilman and Lehman 2001). According to the definition of Seabloom *et al.* (2002) the degree to which spatially aggregated habitat conversion increases species extinctions will depend on the distribution of endemic species within areas of high habitat conversion. The global patterns of extinction dominate in species-rich regions found only within them (namely endemics) (Pimm *et al.* 1995). Finally, according to Luck *et al.* (2004), human population distribution is a threat to the majority of species, regardless of range size.

The Kazakhstan territory is not an exception of the situation of spatially aggregated human activity. To analyse the distribution of endemics, we used "*Kazakhstan Flora*" (9 volumes, published in 1956-1966), the most conservative and total list of plant species habitats, prepared before an essential habitat conversion. Since publication of "*Kazakhstan Flora*", considerable anthropogenic changes have occurred in Kazakhstan over the last 50 years. As a result of the development of virgin and lay lands, especially in steppes, grain crops have largely replaced native vegetation in nearly 9 million ha of arable land subjected to erosion already in the 1960s, just 10 years after the beginning of virgin land development (see Rachkovskaya *et al.* 2003). Over the last 10-15 years, due to human activity, that number worsened after the adoption by Kazakhstan of a new Land Code that legalized the development of private property. Ubiquitous purchase and sale of land, poor land management and inappropriate development, for instance by introduction of alien plant species and overgrazing live stock, further deteriorated the situation. Elevated inclined piedmont plains of Zailyisky, Dzungar Alatau and Karatau subprovinces, in which the greatest quantity of Kazakhstan endemics have been revealed, have much more water and are fertile. For these reasons 30-40% up to >60% of these plains have permanent crops and arable land (see FAO date and **Fig. 1**). The dry mountain steppes and, adjoining to mountains, the dry piedmont plains and desert regions of Kyzyl Kum and Moiyn Kum are sporadically used as pastures. Almaty, the former capital and the largest city in Kazakhstan is situated in the piedmont of Zailyisky Alatau with a population of 1,348,500 (as of September 2008), which represents 9% of the country's population. Karatau Mountains are a region rich with minerals and polymetals. Therefore, in the territory there are a number of ferrous and nonferrous metallurgical and machine-building factories. Thus, the increasing detrimental impact by human activity in Kazakhstan takes place exactly in the areas with considerable diversity and species endemism. The Kazakhstan flora faces extermination in these areas. Species with small ranges, in which endemics are typically scarcer within their ranges compared to more widely distributed species, make endemic species even more vulnerable. Obviously, habitat destruction causes immediate extinction of those endemics, which lived only in destroyed areas, and simultaneously with them extinction of accompanying plant communities.

The greatest probability is for endemics survive in habitats of little human use, for instance in places with high mean elevation (see Seabloom *et al.* 2006) and in natural reserves. There are 10 nature reserves and 8 natural parks in Kazakhstan, although the distribution of national reserves throughout the Kazakhstan territory is sporadic (Ivashenko 2006). For instance, Aksu-Dzabagli (based on 1926) is located in a joint of floristic subprovinces Karatau and the Western Tien-Shan. The national reserve in the middle of Karatau was established only in 2004; Alakolsky national reserve (based on 1998) is in the north-east extremity of Dzungar Alatau, Almaatinsky (in 1935-51, 1961) is situated a very short distance from Almaty. The total area of all 10 national reserves is about 943,250 ha (Ivashenko 2006) and incomparably small to the total Kazakhstan territory (2,717,300 km^2). Unfortunately, the conservation regime of national parks in Kazakhstan frequently does not correspond to international standards (Rachkovskaya *et al.* 2003). In some protected areas agricultural or other kind of human activity is only officially excluded or seriously circumscribed. Even in mountainous zones, where a maximum number of endemics has been described, the conservation status is sometimes not maintained because of the economic use of the land like wood cutting, forest-planting, mowing and alien plant species introduction (Rachkovskaya *et al.* 2003). Alien species introducing results in a further decrease of the floristic differentiation and uniqueness by

taxonomic and phylogenetic homogenization effects (Winter *et al.* 2009).

CONCLUDING REMARKS

Although great effort is being made to digitize existing data from natural history collections for conservation, biodiversity loss is arguably proceeding more rapidly than the documentation of species distributions (Kier *et al*. 2009). According to these authors an inventory-based approach is a workable solution for conservation of vascular plants, a group of organisms which is of outstanding ecological and economical importance for human well-being. In view of all aforesaid there are doubts about the persistence of quite a number of endemics exactly in Kazakhstan floristic areas, at least for those described in the only floristic area in a few locations. The reinventory of Kazakhstan flora endemics should be done urgently according to the international system for classifying species at high risk of global extinction, that is, according to the Categories and Criteria of International Union for Conservation of Nature (IUCN). It is necessary to take into consideration that conserving a single representative sample of each species is a poor substitute for the protection of ecosystem processes, viable species populations, and other elements of biodiversity that are often included in many systematic conservation plans (Luck *et al.* 2004). Conserving endangered plant species in their habitats maximizes the protection of all other accompanying species groups (Dobson *et al.* 1997). According to Myers *et al.* (2000), conservationists are far from able to assist all species under threat. For instance, geographic distribution data for endangered species in the United States were used to locate "hot spots" of threatened biodiversity. If species-rich areas are lost first, one way is to identify 'biodiversity hotspots' where exceptional concentrations of endemic species are undergoing exceptional loss of habitat. Thus, the necessity becomes urgent to outline priorities and to formulate a strategy for corresponding plant species conservation in Kazakhstan.

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