



Floristic Features of the Coastal Zone of Lakes in the “Altyn-Dala” Nature Reserve

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ABSTRACT

This study aimed to investigate the floristic composition and structural features of the aquatic and coastal vegetation of lakes located in the Turgai floristic district within the “Altyn-Dala” Nature Reserve, Kazakhstan. Field research was conducted on 10 water bodies. The floristic composition was analyzed within three ecological zones: the littoral zone, the supralittoral zone, and the lake terrace. Standard geobotanical methods were applied to determine species composition, projective cover, occurrence, and species activity. The calculation of species activity was used to assess the coenotic importance of dominant taxa in each zone. The study recorded 108 species belonging to 76 genera and 29 families of higher vascular plants. The littoral zone included 27 species and was dominated by *Phragmites australis*, followed by *Schoenoplectus tabernaemontani* and *Potamogeton perfoliatus*. The supralittoral zone comprised 53 species, with the highest activity shown by *Agrostis stolonifera*. In saline habitats, halophytic species such as *Chenopodium urbicum*, *Salicornia perennans*, and *Suaeda corniculata* were especially important. The lake terraces contained 65 species and showed clear differentiation between non-saline and saline sites. Only 8 synanthropic and adventive species were identified, including the invasive transformer species *Conyza canadensis*. The results demonstrate pronounced floristic differentiation among coastal zones and confirm the ecological value of the lake systems of the “Altyn-Dala” Nature Reserve for biodiversity conservation.

Keywords: Floristic composition, Lake shores, Littoral zones, Halophytes, Invasive species, Altyn-Dala

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INTRODUCTION

More than 48,000 natural lakes are found in Kazakhstan, about 90% of which are small lakes with an area of less than 1 km². The total surface area of lakes in Northern Kazakhstan exceeds 19,000 km². This region includes more than 11,000 freshwater lakes and about 2,500 saline lakes with water surface areas ranging from 0.01 to 50 km² or more (Palgov, 1960; Shnitnikov & Smirnova, 1975).

In northern Kazakhstan, many lakes were formed in the depressions of ancient rivers. On the Turgai Plateau, the formation of small basins and steppe saucer-like depressions is associated with suffusion and subsidence processes and, in some places, with ancient thermokarst processes in frozen strata. These lakes are sustained by snowmelt and groundwater

feeding. Typically, they are arranged in chains and have an elongated shape. One such chain occupies the ancient valley of the Turgai River. It begins with Lake Kushmurun, includes Lake Sarykopa, and ends with a group of small lakes filled with water during the flooding of the Turgai River. This entire chain of freshwater and saline water bodies, with shores overgrown with reeds or bordered by salt marshes, stretches for more than 500 km (Myakisheva *et al.*, 2013).

These lakes play a key role in seasonal migrations of wetland and water birds along the Tobol–Ishim interfluvium and the Turgai depression, and they serve as important nesting habitats for aquatic bird species.

In November 2012, the State Nature Reserve “Altyn-Dala” was established in the Amangeldin and Zhangel'din districts of the Kostanay Region with a total area of 489,766 hectares (Bragina & Bragin, 2002; Altyn-Dala Conservation Initiative, 2008; Government of the Republic of Kazakhstan, 2012).

Aquatic and coastal plants are an important component of

natural ecosystems and have considerable ecological and economic significance. The intensification of anthropogenic and technogenic impacts, as well as global warming, leads to changes in the floristic composition of aquatic and coastal vegetation, which makes it necessary to conduct an inventory of the floristic composition (Berger *et al.*, 2024; Figueroa-Valverde *et al.*, 2024; Grant & Wallace, 2024; Hodoşan *et al.*, 2024; Almeida *et al.*, 2025; Alves *et al.*, 2025; Lee *et al.*, 2025a, 2025b; Pacheco *et al.*, 2025; Tuleutaev & Kerim, 2025).

The aim of the present study was to investigate the floristic composition of natural lakes in the Turgai floristic district located in the Kostanay Region and included within the "Altyn-Dala" Nature Reserve.

MATERIALS AND METHODS

The lakes under study are part of the endorheic Turgai-Irgiz and Uly-Zhylanshyk river basins. The aridity of the environment, along with the predominance of flat relief, has given the lakes their peculiar hydrographic character (Alavi *et al.*, 2024; Fischer *et al.*, 2024; Mitchell & Simmons, 2024; Muthanandam *et al.*, 2024; Raju, 2024; Umarova *et al.*, 2024; Ba *et al.*, 2025; Cole *et*

al., 2025; Herrera *et al.*, 2025; Morales *et al.*, 2025). The lakes get their water primarily from snow. Summer torrential rains do not generate major changes in water level since the water is virtually entirely lost through evaporation and infiltration. The unstable water level is linked to specific hydrological circumstances (Barinova *et al.*, 2002; Institute of Hydrobiology and Ecology, 2016).

The study area belongs to the Turgai floristic district and largely coincides with the dry-steppe zone of the North Turgai province (Gvozdetsky & Nikolaev, 1971), occupying the northern half of the Turgai table country. In the west it adjoins the hilly plateau of the Trans-Ural region, and in the east, it borders the Kazakh uplands.

Annual precipitation ranges from 210–260 mm, while the sum of temperatures during the growing season reaches 2400–2800°C. The average temperature in January is –18°C, and in July, +23°C. The moisture coefficient in the northern part of steppe Turgai (in the subzone of dark chestnut soils) is 0.30–0.45.

The objects of the study were lakes belonging to the Turgai floristic district, partially located within the territory of the Sarykopa State Nature Reserve (**Table 1**).

Table 1. List of studied objects

No.	Name	Coordinates		Degree of overgrowth, score
		Latitude	Longitude	
1	Lake Shardara, vicinity of Amangeldy settlement	50.188320°	65.219430°	IV
2	Reservoir shore, vicinity of Urpek settlement	50.106404°	65.323439°	IV
3	Reservoir shore, vicinity of Lake Shally	50.312628°	64.334709°	III
4	Lake Sarykopa, Karakol tract	50.437130°	64.238134°	V
5	Lake Sarykopa, Kyzbel rural district	50.381071°	64.322939°	IV
6	Lake Shally, Kyzbel rural district	50.318562°	64.314375°	V
7	Lake Kaskopa, Kumshik tract, vicinity of Kumshik village	50.311983°	64.194087°	V
8	Unnamed lake, Kumkeshusky rural district	50.187882°	64.405398°	I
9	Lake Sarykopa, vicinity of Taush settlement	50.003538°	64.038916°	V
10	Unnamed lake, vicinity of Sarysu settlement	49.911746°	63.800675°	I

From a methodological perspective, it is extremely important to determine the boundaries of a water body, which is particularly significant for the subarid zone of Kazakhstan, where the shoreline changes considerably (high water levels in spring and shallowing by autumn). Therefore, the floristic fragment of the flora of water bodies cannot be interpreted narrowly by considering only the hydrophilic element without including the list of coastal-aquatic plants (Rychin, 1948; Kuzmichev, 1992; Sviridenko, 2000; Kipriyanova, 2005; Durnikin, 2015).

The study of the floristic composition of lakes was carried out in three zones. The littoral zone was defined as the area from the water's edge to the lower boundary of higher flowering plant growth (**Figure 1, I**). Usually, the study was conducted from the shoreline to a depth of 1.5–2.0 m.

The supralittoral zone is the section of the shore periodically flooded during floods and exposed by autumn (**Figure 1, II**). Here a so-called ephemeratum is formed—a set of rapidly developing species in silty, periodically flooded, and dried coastal areas (Taran, 1993, 1995). According to R.J. Naiman *et al.* (1988, 1997), coastal plant communities provide insight into the diversity of species richness at various spatial and temporal scales since they maintain complex habitat patches created and destroyed by hydrological disturbances, which leads to an annual redistribution of species.

The lake terrace is an area usually not flooded in spring and serving as a transitional zone between the floodplain part and zonal vegetation; floristically it contains elements of both the supralittoral zone and zonal vegetation (**Figure 1, III**).

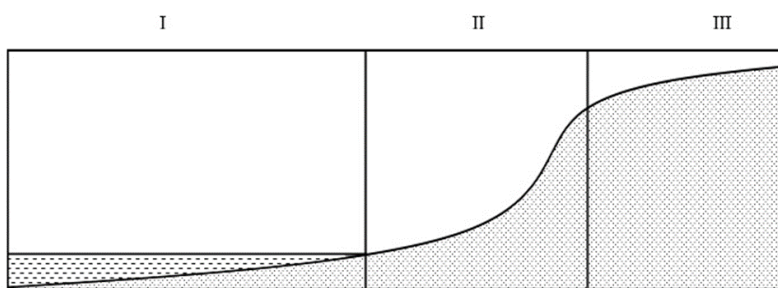


Figure 1. I – littoral zone, II – supralittoral zone, III – lake terrace

According to the **degree of overgrowth of the littoral zone**, the following groups are distinguished (Novikov & Tsaralunga, 2015):

- I – non-overgrown (less than 1%);
- II – weakly overgrown (1–10%);
- III – moderately overgrown (11–25%);
- IV – strongly overgrown (26–50%);
- V – very strongly overgrown (51–95%);
- VI – completely overgrown (100%).

Geobotanical descriptions were carried out in each of the three zones. The area of the sampling plot was 100 m². The total and partial projective cover (%) were determined (Lavrenko & Korshagin, 1976).

Qualitative plant accounting was conducted according to accepted methodologies (Greig-Smith, 1967; Rabotnov, 1992). The number of species (units), occurrence (%), and partial projective cover (%) were determined.

For the overall assessment of the coenotic position of a species, a complex indicator of species activity (%) is used, which reflects the degree of the species' vital success in a given territory and represents one of the expressions of the "weight of

the species" in the given flora (Kupriyanov *et al.*, 2018).

The calculation of species activity was performed in the IBIS system (Zverev, 2007) using the formula:

$$Act = \sqrt{\frac{C \times 100\%}{N} \times \frac{\sum_{i=1}^N A_i}{N}} = 10 \times \sqrt{\frac{C \times A_{\Sigma}}{N}} \% \quad (1)$$

where *Act* – calculated activity of the taxon for the monitoring area in percent (0÷100%);

N – number of sampling plots (elementary one-meter samples);
C – constancy of the taxon – the absolute number of sampling plots where the taxon was recorded;

A_i – projective cover of the taxon in the *i*-th sampling plot;

A_Σ – sum of the projective cover of the taxon across all sampling plots.

RESULTS AND DISCUSSION

The littoral zone is represented by 22 species belonging to macrophytes (**Table 2**).

Table 2. Floristic features of the most active species of the littoral fraction of the flora of the lake shores of Turgai (n=10)

Plant species	Projective cover, %	Occurrence, %	Species activity, %
<i>Phragmites australis</i> (Cav.) Trin. ex Steud.	13,3	50	25,79
<i>Schoenoplectus tabernaemontani</i> (C. C. Gmel.) Palla	5,5	40	14,83
<i>Potamogeton perfoliatus</i> L.	4,1	50	14,32
<i>Butomus umbellatus</i> L.	1,15	40	6,78
<i>Eleocharis palustris</i> (L.) Roem. et Schult.	2,2	20	6,63
<i>Potamogeton crispus</i> L.	1,3	30	6,24
<i>Typha latifolia</i> L.	3,5	10	5,92
<i>Nuphar lutea</i> (L.) Smith.	1,05	20	4,58
<i>Persicaria amphibia</i> (L.) S. F. Gray.	2	10	4,47
<i>Agrostis stolonifera</i> L.	0,55	20	3,32
<i>Typha angustifolia</i> L.	0,55	20	3,32
<i>Bolboschoenus maritimus</i> (L.) Palla	1	10	3,16
<i>Nymphaea candida</i> J. Presl.	1	10	3,16
<i>Alisma lanceolatum</i> With.	0,35	20	2,65
<i>Sagittaria sagittifolia</i> L.	0,35	20	2,65
<i>Myriophyllum spicatum</i> L.	0,5	10	2,24
<i>Oenanthe aquatica</i> (L.) Poir.	0,5	10	2,24

<i>Potamogeton lucens</i> L.	0,5	10	2,24
<i>Bolboschoenus planiculmis</i> (Fr. Schmidt) Egor.	0,4	10	2,00
<i>Hydrocharis morsus-ranae</i> L.	0,3	10	1,73

The highest activity within the littoral zone is shown by *Phragmites australis*, which in most lakes forms either a wide belt or occurs in patches. On average, its occurrence reached 50%, projective cover 13.3%, and activity 25.79%. With a considerable gap, the following species are recorded: *Schoenoplectus tabernaemontani* – activity 14.83%, and *Potamogeton perfoliatus* – activity 14.32%. Among other species with relatively high activity, it should be noted *Butomus umbellatus* – activity 6.78%, *Eleocharis palustris* – activity 6.63%, and *Potamogeton crispus* – activity 6.24%.

The species composition is mainly represented by hydro-hygrophytes (72.7%), among which the most common are *Butomus umbellatus*, *Eleocharis palustris*, *Phragmites australis*, *Schoenoplectus tabernaemontani*, *Typha latifolia*, and others. Hydrophytes are represented by a smaller number (6 species), among which the most common are *Myriophyllum spicatum*, *M. verticillatum*, *Potamogeton crispus*, *P. lucens*, *P. perfoliatus*, and *Salvinia natans*.

Supralittoral Zone. The supralittoral zone is represented by **53 species (Table 3)**.

Table 3. Floristic features of the most active species of the supralittoral fraction of the flora of the lake shores of Turgai (n=10)

Plant species	Projective cover, %	Occurrence, %	Species activity, %
<i>Agrostis stolonifera</i> L.	15	40	24,49
<i>Phragmites australis</i> (Cav.) Trin. ex Steud.	12	30	18,97
<i>Chenopodium urbicum</i> L.	2,9	60	13,19
<i>Bolboschoenus planiculmis</i> (Fr. Schmidt) Egor.	3,6	30	10,39
<i>Xanthium strumarium</i> L.	3,5	30	10,25
<i>Rumex maritimus</i> L.	6	10	7,75
<i>Schoenoplectus tabernaemontani</i> (C. C. Gmel.) Palla	2	20	6,32
<i>Salicornia perennans</i> Willd.	1,3	30	6,24
<i>Plantago major</i> L.	1,1	30	5,74
<i>Potentilla supina</i> L.	0,9	30	5,20
<i>Artemisia nitrosa</i> Web. ex Stechm.	1	20	4,47
<i>Agrostis gigantea</i> Roth	0,65	30	4,42
<i>Alisma lanceolatum</i> With.	0,65	30	4,42
<i>Mentha arvensis</i> L.	0,65	30	4,42
<i>Halimione verrucifera</i> (M.Bieb.) Aellen	0,8	20	4,00
<i>Suaeda corniculata</i> (C. A. Mey.) Bunge	1,5	10	3,87
<i>Tamarix ramosissima</i> Ledeb.	1,5	10	3,87
<i>Aeluropus litoralis</i> (Gouan) Parl.	0,55	20	3,32
<i>Butomus umbellatus</i> L.	1	10	3,16
<i>Elytrigia repens</i> (L.) Nevski	1	10	3,16
<i>Elytrigia repens</i> (L.) Nevski	1	10	3,16
<i>Oenanthe aquatica</i> (L.) Poir.	1	10	3,16
<i>Persicaria amphibia</i> (L.) S. F. Gray.	1	10	3,16
<i>Frankenia hirsuta</i> L.	0,35	20	2,65
<i>Potentilla anserina</i> L.	0,5	10	2,24
<i>Artemisia abrotanum</i> L.	0,5	10	2,24
<i>Atriplex laevis</i> C. A. Mey.	0,5	10	2,24
<i>Carex vesicaria</i> L.	0,5	10	2,24
<i>Pulicaria vulgaris</i> Gaertn.	0,5	10	2,24
<i>Rorippa palustris</i> (L.) Bess.	0,5	10	2,24
<i>Rumex confertus</i> Willd.	0,5	10	2,24
<i>Saussurea amara</i> (L.) DC.	0,5	10	2,24
<i>Sium sisaroides</i> DC.	0,5	10	2,24

In the supralittoral zone, *Agrostis stolonifera* has the highest projective cover (15.0%), occurrence (40%), and activity (24.49%). Its intensive vegetative reproduction is facilitated by

moderate trampling of the coastal zone by livestock. In the supralittoral zone of fresh or slightly saline lakes, high activity is observed for *Phragmites australis* (18.97%), *Bolboschoenus*

planiculmis (10.39%), and *Xanthium strumarium* (10.25%). In the supralittoral zone of saline water bodies, high activity is characteristic of *Chenopodium urbicum* (13.9%), *Salicornia perennans* (6.24%), *Halimione verrucifera* (4.00%), and *Suaeda*

corniculata (3.87%). Such a ratio of species is typical for lake depressions of the "Altyn-Dala" Nature Reserve (Rachkovskaya & Nelina, 2018).

The flora of lake terraces includes 65 species (**Table 4**).

Table 4. Floristic features of the most active species of the supralittoral fraction of the flora of lake terraces of the Turgai lakes (n=10)

Plant species	Projective cover, %	Occurrence, %	Species activity, %
<i>Elytrigia repens</i> (L.) Nevski	11	40	20,98
<i>Suaeda corniculata</i> (C. A. Mey.) Bunge	4,4	60	16,25
<i>Festuca valesiaca</i> Gaud.	2,25	70	12,55
<i>Tamarix ramosissima</i> Ledeb.	7,5	20	12,25
<i>Halimione verrucifera</i> (M.Bieb.) Aellen	2,8	50	11,83
<i>Artemisia serotina</i> Bunge	3,5	30	10,25
<i>Aeluropus littoralis</i> (Gouan) Parl.	2,55	40	10,10
<i>Artemisia nitrosa</i> Web. ex Stechm.	1,9	40	8,72
<i>Taraxacum turgaicum</i> Schischk.	3,3	20	8,12
<i>Pulicaria vulgaris</i> Gaertn.	1,6	30	6,93
<i>Limonium gmelinii</i> (Willd.) Kuntze	1,15	40	6,78
<i>Artemisia aralensis</i> Rrasch.	1,3	30	6,24
<i>Salicornia perennans</i> Willd.	1,3	30	6,24
<i>Pseudosphora alopecuroides</i> (L.) Sweet	1,5	20	5,48
<i>Xanthium strumarium</i> L.	1,5	20	5,48
<i>Artemisia sieversiana</i> Willd.	2	10	4,47
<i>Puccinellia distans</i> (Jacq.) Parl.	1	20	4,47
<i>Artemisia pauciflora</i> Weber	0,8	20	4,00
<i>Saussurea amara</i> (L.) DC.	0,6	20	3,46
<i>Achillea nobilis</i> L.	1	10	3,16
<i>Artemisia abrotanum</i> L.	1	10	3,16
<i>Schoenoplectus tabernaemontani</i> (C. C. Gmel.) Palla	1	10	3,16

A specific feature of lake terraces is the combination of species from the supralittoral zone and communities of zonal vegetation (Castellano-Rioja et al., 2024; Mitchell & Simmons, 2024; Thompson et al., 2024; Umarova et al., 2024; Zielinska & Kowal, 2024; Ahmed et al., 2025; Figueroa-Valverde et al., 2025; Gurung & Rai, 2025; Schneider & Krüger, 2025; Smith et al., 2025). On lake terraces composed of light, non-saline sandy-loam soils, the highest projective cover (11.0%) and activity

(20.98%) are recorded for *Elytrigia repens*, while *Festuca valesiaca* shows an activity of 12.55%. On the terraces of saline lakes, the highest activity is characteristic of halophytic plants: *Suaeda corniculata* (16.25%), *Halimione verrucifera* (11.83%), *Artemisia serotina* (10.25%), and *Aeluropus littoralis* (10.10%). The total floristic list of the shores of the studied lakes includes 108 species, belonging to 76 genera and 29 families of higher vascular plants (**Table 5**).

Table 5. Systematic composition of the flora of the lake shores of Turgai

Families	number of genera	number of species	% of total number of species
Asteraceae Dumort.	14	26	24,1
Chenopodiaceae Vent.	11	14	13,0
Poaceae Barnhart	9	11	10,2
Polygonaceae Juss.	2	6	5,6
Cyperaceae Juss.	4	5	4,6
Apiaceae Lindl.	4	4	3,7
Lamiaceae Lindl.	3	4	3,7
Alismataceae Vent.	2	3	2,8
Fabaceae Lindl.	3	3	2,8
Plumbaginaceae Juss.	2	3	2,8
total	54	79	73,1
The remaining 19 families: Brassicaceae Burnett, Butomaceae L. C. Rich., Caryophyllaceae Juss., Frankeniaceae S.F.Grey, Hydrocharitaceae Juss., Juncaceae Juss., Malvaceae Juss., Nymphaeaceae Salisb., Plantaginaceae Juss.,	22	29	26,9

Potamogetonaceae Dumort., Ranunculaceae Juss., Rosaceae Juss., Salicaceae Mirb., Salviniaceae Reichenb., Scrophulariaceae Juss., Solanaceae Juss., Sparganiaceae Rudolphi, Tamaricaceae Link, Typhaceae Juss.

Ten families include 54 species, accounting for 73.1% of all species. Asteraceae is the most extensively represented family, with 26 species (24.1%). Chenopodiaceae comes in second with 14 species (13.0%), followed by Poaceae, which has 11 species (10.2%). Chenopodiaceae's high position is linked to the occurrence of salty lakes and the establishment of a halophytic species complex along their shores (Rachkovskaya & Nelina, 2018). The most numerous genera is Artemisia, which has ten species. In general, coastal-aquatic plants primarily belong to dicotyledonous plants, while the only example of spore plants is Salvinia natans (L.). All.

As the phytocoenotic analysis showed, a small number of synanthropic and adventive plants were recorded in the flora of the lake shores – 8 species, which constitutes 7.3%. Among the synanthropic species, the invasive species *Conyza canadensis* (L.) Cronquist was found (Unnamed Lake, Kumkeshusky rural district). The natural range of *C. canadensis* covers most of the United States, reaching as far south as the states of Texas and Oregon (Torrey & Gray, 1969; Weaver, 2001; Vinogradova et al., 2010).

Currently, *C. canadensis* is distributed in Europe and Asia, including in the flora of Kazakhstan (Vinogradova et al., 2010; Vinogradova et al., 2011). *Conyza canadensis* belongs to transformer species, which actively invade natural and semi-natural communities, alter ecosystem structure, disrupt successional relationships, act as edifiers and dominants, forming extensive monodominant thickets and displacing or preventing the regeneration of species of the natural flora.

CONCLUSION

The aquatic and coastal flora of 10 water bodies located within the Turgai floristic district, partially included in the "Altyn-Dala" Nature Reserve, was studied.

The total floristic list of the shores of the studied lakes includes 108 species belonging to 76 genera and 29 families of higher vascular plants.

The littoral zone is represented by 27 species. The highest activity in the littoral zone is shown by *Phragmites australis*, which forms either wide belts or patchy stands in most lakes. On average, its occurrence reached 50%, projective cover 13.3%, and activity 25.79%. With a considerable gap, the following species are recorded: *Schoenoplectus tabernaemontani* – activity 14.83%, and *Potamogeton perfoliatus* – activity 14.32%.

The supralittoral zone is represented by 53 species. *Agrostis stolonifera* has the highest projective cover (15.0%), occurrence (40%), and activity (24.49%). In the supralittoral zone of fresh or slightly saline lakes, high activity is shown by *Phragmites australis* (18.97%), *Bolboschoenus planiculmis* (10.39%), and *Xanthium strumarium* (10.25%). In the supralittoral zone of saline water bodies, high activity is characteristic of *Chenopodium urticum* (13.9%), *Salicornia perennans* (6.24%), *Halimione verrucifera* (4.00%), and *Suaeda corniculata* (3.87%). The flora of lake terraces includes 65 species. On lake terraces composed of light non-saline sandy-loam soils, the highest projective cover (11.0%) and activity (20.98%) were recorded for *Elytrigia repens*, while *Festuca valesiaca* showed an activity

of 12.55%. On terraces of saline lakes, the highest activity is observed in halophytic plants: *Suaeda corniculata* (16.25%), *Halimione verrucifera* (11.83%), *Artemisia serotina* (10.25%), and *Aeluropus litoralis* (10.10%).

A small number of synanthropic and adventive plants were recorded in the flora of the lake shores — 8 species, representing 7.3%. Among the synanthropic species, the invasive species *Conyza canadensis* (L.) Cronquist was identified — a North American species rapidly spreading in Kazakhstan. *C. canadensis* belongs to transformer species that actively invade natural and semi-natural communities, alter ecosystem structure, disrupt successional relationships, act as edifiers and dominants, and form extensive monodominant thickets.

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