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Review

# Vegetation, fauna, and biodiversity of the Ile Delta and southern Lake Balkhash — A review

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ABSTRACT

Following the desiccation of the Aral Sea, Lake Balkhash has become the largest lake of Central Asia with an area of 17,000 km$^2$. 70%–80% of the annual inflow into Lake Balkhash is delivered by the Ile River. The Ile Delta, 8000 km$^2$ large, is the largest natural delta and wetland complex of Central Asia and therefore is of crucial significance for the biodiversity of that region. In this paper, we reviewed the literature available with regard to vegetation, fauna, and biodiversity of the *Ile River Delta and South Lake Balkhash Ramsar Site*, in order to identify threats and research gaps. Threats are reduced runoff of the Ile River due to increasing water consumption upstream, overfishing, fires ignited by local people, logging for fuel wood collection, over-grazing, and water pollution from upstream. Major research gaps to be addressed are: 1) impact of reduced discharges of the Ile River on the wetland ecosystems and associated changes in livestock grazing, 2) impact of reduced discharges on spawning grounds for fish, 3) upper harvest limits for the fishery, and 4) regrowth of riparian woodlands.



**Contents**



## Introduction

Central Asia is a region largely covered by drylands (MEA, 2005). Under such conditions water is the major driver for the persistence of the current natural ecosystems and their associated biodiversity and

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possible land use activities. The most productive and diverse ecosystems in the drylands of Central Asia are located along the rivers (Ogar, 2003), e.g. reed beds (Thevs et al., 2007) and riparian forests (Thevs et al., 2012). Following the desiccation of the Aral Sea (EC-IFAS, 2012; UNEP, 2014), Lake Balkhash has become the largest lake of Central Asia with an area of about 17,000 km$^2$. 70%–80% of the annual inflow into Lake Balkhash is delivered by the Ile River (Ili River in Russian, Ile River in Kazakh), while the remaining 20%–30% stem from the four rivers Karatal, Aksu, Lapsi, and Ayaköz (Fig. 1). At its mouth, the Ile River has formed a delta with an area of about 8000 km$^2$. The Ile Delta is the largest natural delta and wetland complex at an inland lake, which still receives water permanently, in the whole region of Central Asia, since the Amu Darya Delta shrunk considerably in the course of the Aral Sea desiccation (Ramsar Convention, 2012). Accordingly, the Ile Delta and the southern part of Lake Balkhash have been designated the *Ile River Delta and South Lake Balkhash Ramsar Site* (Ramsar Convention, 2012).

While much research work has been devoted to the Aral Sea (e.g. Breckle et al., 2012; Kostianoy and Kosarev, 2010) and to its tributaries (e.g. Martius et al., 2012), the Ile River Basin and Lake Balkhash have received much less attention from scientists and development agencies. There are concerns that Lake Balkhash may shrink or even desiccate like the Aral Sea and that the Ile Delta may degrade severely due to water abstraction along the rivers of the Ile-Balkhash Basin (Propastin, 2013; UNEP, 2004). He et al. (2014) state that the whole Ile Balkhash Basin is at risk, due to increased water use mainly by agriculture along the Ile River upstream in China and Kazakhstan. Being an endorheic river basin with a relatively non-degraded terminal lake and wetland ecosystems representative for Central Asia, the Ile River Basin offers opportunities to study such wetlands and adjacent natural ecosystems with their vegetation and fauna in a relatively non-degraded setting, and to protect such a wetland complex.

The objective of this review is to describe the status of the biodiversity, including threats for biodiversity, and identify research gaps through a review of the available information with respect to vegetation and fauna of the Ile Delta and southern Lake Balkhash (i.e. the *Ile River Delta and South Lake Balkhash Ramsar Site*). This review additionally makes these sources available to an international readership. As the delta with its natural ecosystems and Lake Balkhash depend mainly on the inflow from the Ile River, information with respect to the water resources of the Ile River Basin and the whole Ile-Balkhash Basin will also be presented.

## Water resources and land use in the Ile Balkhash Basin

The Ile River's two source rivers, i.e. Künez and Tekes, have their headwaters in the Tian Shan Mountains in Xinjiang, China (Fig. 1) as does the largest tributary of the Ile, the Kash River. Thus, about two thirds of the Ile runoff are generated in Xinjiang, China, as shown in Table 1 (Christiansen and Schöner, 2004). Melt water from glaciers and snow as well as rainfall form the discharge of the Ile River (Unger-Shayesteh et al., 2013). For Kazakhstan the Ile-Balkhash Basin is of high significance, as 22% of the water resources of the country are concentrated here (Yerzhanova and Huszti, 2013).

During the 1960s, an average of 15 km$^3$/yr water were drained into Lake Balkhash, with 12 km$^3$/yr coming from the Ile River and three km$^3$/yr from the four minor rivers Karatal, Aksu, Lapsi, and Ayaköz (Fig. 1). Additionally, three km$^3$ of precipitation fell on average over the lake surface per year so that Lake Balkhash gained 18 km$^3$/yr. The lake area was 18,000 km$^2$ in area during the 1960s. The annual evaporation was 1000 mm/yr on average, thus amounting to 18 km$^3$/yr over the lake surface area and being equal to the water gained (Dostaj et al., 2006, 2012). In 1970, the dam of the Kapchagay Reservoir on the Ile River (Fig. 1) in today's Kazakhstan was constructed and the reservoir was filled during the 1970s. During that time the area under irrigation was increased also. Thus, after 1970 the runoff of the Ile River into Lake Balkhash shrunk so that the total inflow into the lake decreased from 15 km$^3$/yr to about 12.2 km$^3$/yr–12.9 km$^3$/yr (Abdrasilov and

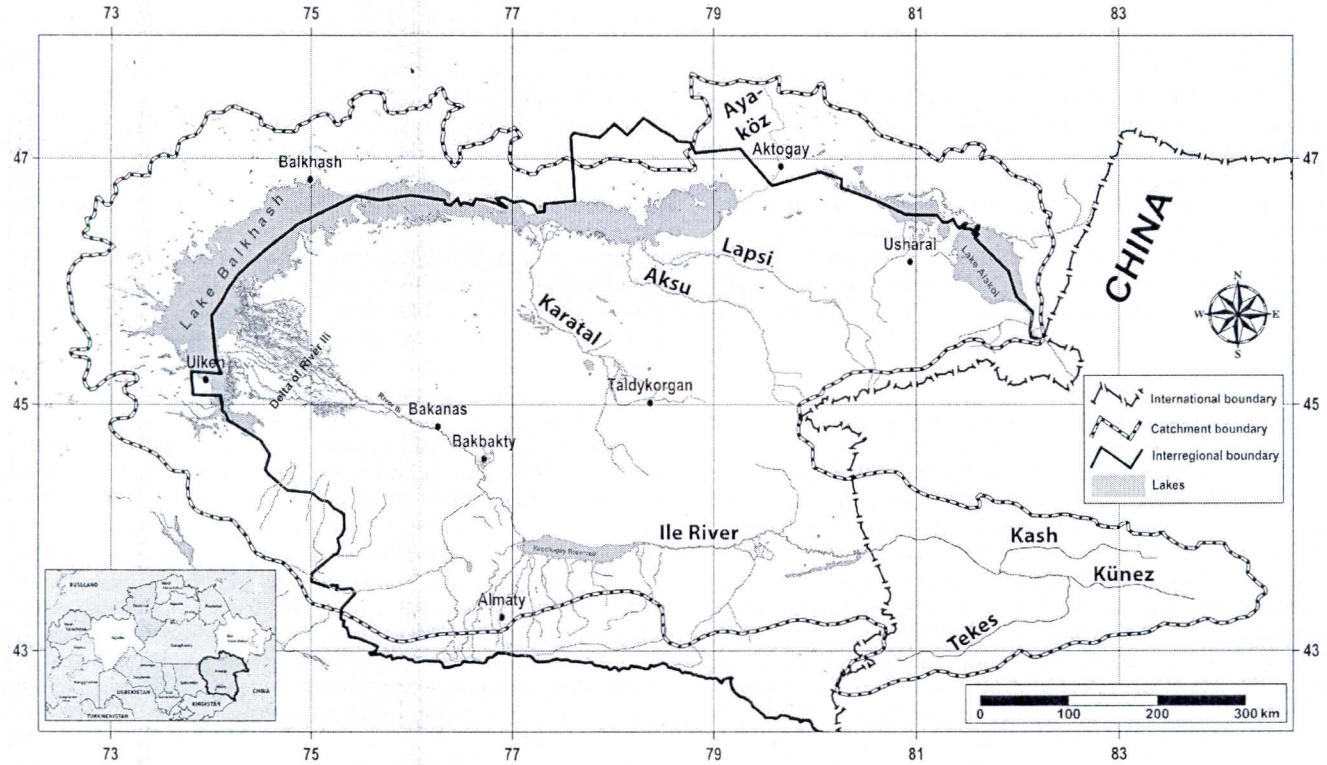


**Fig. 1.** Map of the Ile Balkhash Basin with its boundary (referred to as catchment boundary) and with the major rivers and irrigated areas. After Christiansen and Schöner, 2004, modified after Dostaj, 1999.

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**Table 1**
Long-term average annual runoff of the Ile River and its tributaries prior to construction of the Kapchagay Reservoir (Dostaj et al., 2006).

| Ile catchment | Annual runoff [km³/yr] |
|---|---|
| *China* | |
| Tekes | 8.48 |
| Kash | 4.47 |
| Künez | 2.27 |
| Rivers from the southern slope of the Zhetysuskij-Alatau | 1.55 |
| Rivers from the northern slope of the Uzynkara | 0.27 |
| Total runoff generated in China | 17.04 |
| *Kazakhstan* | |
| Rivers from the southern slope of the Zhetysuskij-Alatau | 1.15 |
| Rivers from the northern slope of the Uzynkara | 1.58 |
| Rivers from the northern slope of the Alatau und Shilek | 2.60 |
| Kurty | 0.39 |
| Rivers from the boundary between Ile and Chu catchments | 0.10 |
| Total runoff generated in Kazakhstan | 5.83 |
| Total runoff generated in the Ile Catchment | 22.87 |

Tulebaeva, 1994; Petr, 1992). As the precipitation and the evaporation did not change (Dostaj et al., 2006), the water balance of the lake became negative (Guo et al., 2011; Petr, 1992). In 1983, Lake Balkhash reached a water level of 341 m a.s.l. which was 2 m below the level during the 1960s. The lake area shrunk to 16,000 km². Concerns were raised that Lake Balkhash may turn into a second Aral Sea (Dostaj et al., 2006).

In the Ile Delta, after the Kapchagay Reservoir was constructed, the area of open water was reduced from 1209 km² to 354 km² from 1974 to 1985. The groundwater level in the Ile Delta sank also. It was also observed that the river branches cut into the previous river beds, as was the case in the Amu Darya Delta of the Aral Sea. Reed beds and riparian forests, the so-called Tugai forests, were degraded in parts of the Ile Delta due to the sinking groundwater levels (Kipshakbaev and Abdrasilov, 1994).

The year 1988 was a positive turning point for the Ile River and Lake Balkhash, as the Kapchagay Reservoir was not further filled (Aladin and Plotnikov, 1993). From 1993 to 1995, the inflow into Lake Balkhash increased to near or above 15 km³/yr again. In 2002, inflow peaked at 26.3, but gradually fell again to 15 km³/yr in 2009 (Esekin et al., 2011). By 2003, the water level in Lake Balkhash had risen to 342 m a.s.l. again (Deng et al., 2011; Esekin et al., 2011; Tursunov, 2002).

Irrigation is the major water user in the Ile Balkhash Basin accounting for 85% of all water use (Kenshimov et al., 2011). In the Kazakh part of the Ile Balkhash Basin, there were 600,000 ha irrigated fields by the end of the 1980s (Tsytsenko, 1988), which fell to 300,000 ha in 2000 (Dostaj et al., 2006). During the past five years, the irrigation systems in the Kazakh part of the Ile River Basin have been restored, resulting in increasing water withdrawal (Starodubtsev and Truskavetskiy, 2011). Also, there is a general trend of increasing total area of arable land in Kazakhstan from 2000 to the present after it had dropped sharply after independence (http://faostat3.fao.org/home/E). Today, the Ile River Basin harbors most of Kazakhstan's irrigated area, which amounts to 447,500 ha irrigated fields, 41,400 ha of pasture land, and 11,900 ha of hay meadows (Burlibaev et al., 2011). The major crops are rice, sugar beets, tobacco, maize, fruits, and vegetables. In total, 41% of the water abstracted is lost as seepage from unlined channels, which causes salinization of soils (Burlibaev et al., 2011). In the Ile Delta, the major land use is animal herding with *Phragmites australis* (common reed) being the major fodder plant (Hirschelmann, 2014). The Kazakh part of the Ile-Balkhash Basin is home to 3.3 million people, which is one fifth of the total population of Kazakhstan. The large majority of that population lives in the Ile River Basin, which includes the City of Almaty with its population of 1.45 million people (Bragin, 2009; Burlibaev et al., 2011).

The part of the Ile Balkhash Basin lying in China corresponds to the Ile Autonomous Kazakh Prefecture (hereafter Ile Prefecture). This prefecture covers an area of 56,300 km² and is home to a population of 4.62 million people (Xinjiang Statistics Bureau, 2014). In 2000, there were 600,000 ha to 650,000 ha under irrigation in the Ile Prefecture (Christiansen and Schöner, 2004), which doubled to 1.2 million ha by 2013 (Xinjiang Statistical Bureau, 2014). The major crops are grains (wheat and corn), oilseeds (rape and sunflower), and cotton (Luo and Gao, 2011; Xinjiang Statistical Bureau, 2014). The Ile River Basin in China is considered to offer the most favorable conditions for agriculture in Xinjiang. Therefore, the Ile Prefecture has been indicated as key-region for further agricultural development (Luo and Gao, 2011).

## Water resource management in the Ile River Basin

In Xinjiang, China, the Xinjiang Water Resource Administration under the Government of Xinjiang is responsible for the administration of the water resources. Under the Xinjiang Water Resource Administration, there is the Ile Basin Water Resource Bureau, which has branches in each county, in order to carry out and monitor water allocation to water users.

In Kazakhstan, the administration of water resources was under the Ministry of Environment and Water Resources prior to August 2014, at which time, the responsibility for water resources was transferred to the Ministry of Agriculture. Under that Ministry, the Committee for Water Resources (CWR) is the main governmental agency which administers the country's water resources. The rivers of the country are assigned to eight river basins. The Balkhash-Alakol Basin, which corresponds to the Ile Balkhash Basin and the Alakol-Sassykol Lakes, is one of those eight river basins. Under the CWR there are inspection and monitoring institutions for each of those eight river basins (Kenshimov et al., 2011). The water allocation within the Kazakh part of the Balkhash-Alakol Basin to the different water users is regulated by the governments at provincial level, i.e. Almaty Province for the Ile River and the other four tributaries to Lake Balkhash (Kenshimov et al., 2011).

From 1998 to 2001, Kazakhstan and China held five rounds of consultations with respect to their shared rivers. In 2001, an agreement on the utilization and protection of those transboundary rivers was signed between the two governments (Kenshimov et al., 2011), and the Kazakh–Chinese Joint Commission on the utilization and protection of the transboundary rivers was established. The Commission has held annual meetings since 2003, during which issues of water quality and natural disasters along the Ile River and other transboundary rivers were discussed (http://www.inform.kz/eng/article/2659180, accessed 10 April 2014). However the issue of water allocation between China and Kazakhstan has not been negotiated and resolved (Williams, 2013).

## The *Ile River Delta and South Lake Balkhash Ramsar Site*

In 2012, the Ile Delta and southern Lake Balkhash region were added to the List of Wetlands of International Importance as the *Ile River Delta and South Lake Balkhash Ramsar Site*. This Ramsar Site covers an area of 976,630 ha and is situated within the borders of the three State Nature Sanctuaries of Republican Importance – Balkhash, Karroy, and Kukan – which together cover an area of 1,061,100 ha. The Ramsar Site contains three Important Bird Areas (IBA): Ile Delta (574,300 ha), Topar Lake System (32,530 ha), and Lower Reaches of the Karatal River (102,195 ha) (Ramsar Convention, 2012). All three State Nature Sanctuaries within this Ramsar Site are under the management of the Altyn-Emel National Park. The management of that park includes wildlife protection and monitoring of ecosystems. The Territorial Inspection for Forestry and Hunting agency of Almaty Province is responsible for the administration of the Ramsar Site.

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### Vegetation and fauna of the Ile Delta and southern part of Lake Balkhash

The Ile Delta covers an area of 8000 km$^2$. It is a hotspot of plant and animal biodiversity and its productivity is of significance for all of Central Asia (Kipshakbaev and Abdrasilov, 1994; Ramsar Convention, 2012; Tsytsenko, 1988). The Ile Delta is a mosaic of habitats and vegetation types, including perennial and seasonal river branches and lakes with reed beds, riparian forests (Tugai), halophytic meadows, desert meadows, and shrub vegetation in the Russian vegetation classification, which is used in this paper (Ogar, 2003; Ramsar Convention, 2012; Sivanpillai et al., 2006).

Reed beds are periodically or permanently submerged. They are mostly species-poor vegetation dominated by *P. australis* (common reed), *Typha angustifolia* (cattail), *Bolboschoenus maritimus* (sedge family), *Elytrigia repens* (couch grass), or *Calamagrostis epigejos* (wood small-reed). *P. australis* forms almost all of the reed beds in the Ile Delta (Ogar, 2003; Ramsar Convention, 2012).

The riparian forests in the Ile Delta, also called Tugai forests in the Russian and some of the international literature (Ogar, 2003; Thevs et al., 2008; Treshkin, 2001), are composed of the willow species *Salix soongorica*, *Salix wilhelmsiana*, *Salix caspica*, *Salix cinerea*, *Salix serrulatifolia*, and *Salix alba*, the poplar species *Populus pruinosa*, *Populus euphratica* (syn. *P. diversifolia*), and *Elaeagnus oxycarpa* (Russian olive) in the tree layer, with *E. oxycarpa* being the dominant tree species in the delta (Haeberlein and Kaiser, 2014). *Tamarix ramosissima*, *Tamarix laxa* (saltcedar or tamarisk species), *Halimodendron halodendron* (Russian salt tree), *Glycyrrhiza uralensis*, *Glycyrrhiza glabra* (Liquorice), *Apocynum venetum* (Turkistan hemp, dogbane family), *P. australis* (common reed), *C. epigejos* (wood small-reed), and *Leymus multicaulis* (lyme grass) form the undergrowth. The climbing species *Clematis orientalis*, *Cynanchum sibiricum*, and *Calystegia sepium* are also found in these forests (Ogar, 2003). The Tugai forests are found in the upstream part of the Ile Delta and along the southern main river branch of the delta. They mostly form narrow strips along the active river branches or lake shores. Within such strips, *E. oxycarpa* and *P. euphratica* cover most of the area, while the willow species are restricted to sites directly adjacent to the water (Rachkovskaya et al., 2003).

Halophytic meadows are formed on sites which are not or seldom submerged, with groundwater levels of 1.5–2.5 m below the surface (Ogar, 2003). These meadows are mainly distributed on natural levees or flat dunes in the downstream parts of the Ile Delta. The dominant species are the grasses (Poaceae) *Aeluropus littoralis*, *L. multicaulis*, *Hordeum bogdanii*, *Puccinellia distans*, and *Puccinellia tenuiflora*. The following halophytic herbs are found as accompanying species: *Limonium otolepis*, *Limonium gmelinii* (sea-lavender), *Saussurea salsa*, *Plantago salsa* (fleawort), *Suaeda acuminata*, *Suaeda prostrate* (seepweeds), *Climacoptera brachiata*, *Climacoptera lanata* (Ramsar Convention, 2012).

Desert Meadows are distributed on terraces along active river branches or on old flood plains with groundwater levels deeper than 2.5 m below the surface. Desert Meadows are formed by xeromesophytic and halophytic–xeromesophytic plant species. The most widespread species are *Alhagi pseudalhagi* (camel thorn), *T. ramosissima* (saltcedar), *H. halodendron* (Russian salt tree), *Krascheninnikovia ceratoides* (Amaranth family), *L. otolepis* (Plumbago family), *G. uralensis*, *G. glabra* (Liquorice), *A. venetum* (Turkistan hemp, dogbane family), as well as salt-resistant grasses like *A. littoralis*, *P. distans*, *Puccinellia dolicholepis*, and *Puccinellia tenuissima* (Rachkovskaya et al., 2003; Ramsar Convention, 2012).

The shrub vegetation splits into *Tamarix* (saltcedar or tamarisk) dominated areas, *Haloxylon aphyllum* (black saxaul) dominated areas, and shrub communities dominated by halophytes, e.g. *Halostachys caspica* or *Halocnemum strobilaceum* (Ogar, 2003). Such shrub vegetation is distributed on terraces along active river branches or on flood plains and alluvial plains; often shrub vegetation is adjacent to Desert Meadows and forms the boundary with the desert which surrounds the delta.

The desert around the delta is covered by a sparse psammophytic vegetation with *Haloxylon persicum* (white saxaul), *Artemisia songorica* (sagebrush), *Ammodendron bifolium* (sand acacia), and *Calligonum* species (knotweed or buckwheat family) as dominant species. At the boundary between the delta and the surrounding desert, the dune valleys are partly filled with water that forms perennial or periodic lakes. The peaks and slopes of the dunes are covered with the psammophytic vegetation, while the downslopes of the dunes are covered by phreatophytic species such as *Karelinia caspica*, *A. pseudalhagi*, *T. ramosissima* and *H. halodendron*. Along the shores of the lakes in the dune valleys *P. australis* and Tugai forest species are commonly found (Haeberlein and Kaiser, 2014).

Along the shoreline of Lake Balkhash the dominant plant species are emerged macrophytes, *P. australis*, *Typha angustata* and three species of sedges: *Schoenoplectus litoralis*, *Schoenoplectus lacustris* and *Scirpus kasachstanicus* (World Lake Database, 2014). The latter three sedge species are endemic. The aquatic vegetation includes communities of *Butomus umbellatus* (grass rush), *Eleocharis acicularis* (spikesedge), *Najas marina* (spiny water nymph), *Myriophyllum spicatum* (watermilfoil), *P. australis*, *Polygonum amphibium* (water knotweed), *Thelypteris palustris* (marsh fern), and other species in the genera *Potamogeton* (pondweed), *Sagittaria* (duck potato), *Scirpus* (clubrush), and *Sparganium* (cattail family). The free-floating vegetation includes the following species: *Lemna minor* (common duckweed), *Utricularia vulgaris* (common bladderwort), and *Ceratophyllum demersum* (hornwort). This aquatic vegetation is also found in the lakes of the downstream part of the Ile Delta (Ramsar Convention, 2012).

The plant species of the riparian forests, meadow vegetation, and most species of the shrub vegetation survive under the arid climate because they take up groundwater as obligate or facultative phreatophytes (Chou, 1960; Huang, 1986; Kuzmina and Treshkin, 1997; Lavrenko, 1956, 1961; Lavrenko et al., 1991; Novikova, 2001; Ogar, 2003; Schlüter et al., 2006; Sukhova and Gladyshev, 1980; Thevs et al., 2007, 2008; Wang et al., 1996; Xinjiang Linkeyuan Zaolin Zhisha Yanjiusuo, 1989). *P. australis* and the tree species of the Tugai forests are obligate phreatophytes, i.e. these species must have continuous contact to the groundwater (Gries et al., 2003; Thomas et al., 2006). In contrast, *Tamarix*, *H. aphyllum*, and other halophytic shrubs are facultative phreatophytes and thus are able to survive some time period disconnected from the groundwater by using soil moisture from the unsaturated zone (Smith et al., 1998).

In total, there are 427 species of vascular plants from 241 genera and 68 families in the Ile Delta and Lake Balkhash. There are seven relict species: *Nitraria sibirica*, *Nitraria schoberi*, *Peganum harmala* (family *Nitrariaceae*), *Nymphaea candida* (water lily), *Arthrophytum balchaschense* (goosefoot family), *P. euphratica*, and the grass species *Achnatherum splendens*. Furthermore, there are 18 endemic species: *Astragalus balchaschensis* (legume family), *Dendrostellera ammodendron* (family *Thymelaeaceae*), *Megacarpaa iliensis* (crucifer family), *Linaria pedicellata*, *L. ramose* (genus *Linaria*, i.e. flax), *Euphorbia sororia*, *Zygophyllum fabagoides*, *Artemisia albicerata* (sagebrush), *Kalidium schrenkianum* (amaranth family), *Eremostachys rotala* (deadnettle family), *Tulipa behmiana*, *Rosa iliensis*, *Ephedra lomatolepis*, and (from the daisy family) *Microcephala subglobosa*, *Echinops albicaulis*, *Jurinea adenocarpa*, *Saussurea robusta*, and *Chondrilla bosseana*. The following seven species are classified as rare according to the red list of endangered species of Kazakhstan (Ramsar Convention, 2012; Sultanova et al., 2012): *S. kasachstanicus*, *P. pruinosa*, *Nymphoides peltatum* (a small water lily), *Aldrovanda vesiculosa* (water wheel), *Nelumbo nucifera* (Indian lotus), *Berberis iliensis*, and *Lonicera ileensis* (honeysuckle).

### Fauna of Lake Balkhash and the Ile Delta

Lake Balkhash and the Ile Delta harbor 25 fish species and 345 terrestrial vertebrate species, among them are 284 bird and 39 mammal species (Ramsar Convention, 2012; Sultanova et al., 2012). The delta

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and southern part of Lake Balkhash furthermore support a range of threatened species, including one fish, 25 bird, and three mammal species as listed in Table 2 (Sultanova et al., 2012).

### *Zooplankton*

Zooplankton of Lake Balkhash were investigated during several expeditions between 1929 and 1944. In total, 57 taxa of zooplankton with 312 species were recorded (Abrosov, 1973). The rotifers dominate the zooplankton in the open water. Among them the most common rotifer species were ers *Keratella cochlearis*, *Keratella quadrata*, *Filenia longiseta*, *Polyarthra platyptera*, and *Asplanchna herricki*. Copepods and cladocerans play a major role in the plankton of the littoral zone with the dominant species being *Arctodiaptomus salinus*, *Diaphanosoma lacustris*, *Mesocyclops leuckarti*, *Thermocyclops crassus*, and *Daphnia galeata* in the eastern part of the lake (Petr, 1992; Krupa et al., 2013). The invertebrate populations have been increasing in terms of biomass since the regulation of the Ile River runoff (Krupa et al., 2013).

### *Zoobenthos*

The zoobenthos of Lake Balkhash is rather species-poor. According to Zhadin (1952) only five mollusks were found in lake: *Bithynia coerulans* (endemic), *Valvata piscinalis*, *Gyraulus ehrenbergi*, *Radix auricularia*, and *Pisidium henslowanum*. From the Ile Delta *Lymnaea truncatula*, *Lymnaea peregra*, *Gyraulus ehrenbergi*, and *Amphipeplea glutinosa* have been recorded. Among the annelids, three species of leeches (*Piscicola geometra*, *Protoclepsis meyeri*, and *Glossiphonia complanata*) and eight oligochaetes (*Potamothrix hammoniensis*, *Potamothrix bavaricus*, *Limnodrilus profundicola*, *Limnodrilus hoffmeisteri*, *Tubifex tubifex*, *Uncinais uncinata*, *Nais pardalis*, and *Stylaria lacustris*) were found in Lake Balkhash (Petr, 1992). In the Ile Delta the following chironomids were reported: *Chironomus salinarius*, *Ch. plumosus*, *Glyptotendipes gripekoveni*, *Endochironomus nymphoides*, and *Ablabesmyia mobiles* and the genera *Parachironomus*, *Prochironomus*, *Stictochironomus*, *Polypedilum*, *Cryptochironomus*, *Harnischia*, *Tanytarsus*, *Tanypus*, and *Protenthes* (Petr, 1992). The zoobenthic fauna of Lake Balkhash also contains a steadily increasing number of introduced species (Aladin et al., 2013). During the period 1961–1971 mysids, polychaetes, mollusks, and an amphipod were introduced: *Hypania invalida* and *Hypaniola kowalevskyi* (polychaetes), *Monodacna colorata*, *Anodonta cellensis*, and *Anodonta cygnea* (mollusks), the mysids *Paramysis intermedia*, *Paramysis kowalevskyi*, *Paramysis ulakyi* and *Paramysis baeri*, and the amphipod *Corophium curvispinum* (Petr, 1992). During the last decades, the population of *M. colorata* increased by 95.6% due to a decline of common carp (*Cyprinus carpio*) and other fishes that feed on zoobenthos (Krupa et al., 2013).

In the Ile Delta the zoobenthos is more diverse than in Lake Balkhash. Various mollusks, larvae of *Trichoptera*, *Plecoptera*, and *Heteroptera*, also Chironomidae and Oligochaetes were found in the delta (Abrosov, 1973). The composition and distribution of zoobenthos depend directly on the types of substrate, mineralization, and indirectly on water level. As zoobenthos is the main food resource for fish, e.g. common carp (*C. carpio*), their abundance has impacts on fish populations (Abrosov, 1973).

**Table 2**
List of threatened fish, bird, and mammal species in the Ile Delta (Ramsar Convention, 2012). The IUCN status refers to: LC – least concern, NT – near threatened, VU – vulnerable, EN – endangered, CR – critically endangered.

| English name | Scientific name | IUCN status |
|---|---|---|
| *Fish* | | |
| Ship sturgeon | *Acipenser nudiventris* | CR |
| *Birds* | | |
| White pelican | *Pelecanus onocrotalus* | LC |
| Dalmatian pelican | *Pelecanus crispus* | VU |
| Eurasian spoonbill | *Platalea leucorodia* | LC |
| Red-breasted goose | *Branta ruficollis* | EN |
| Whooper swan | *Cygnus cygnus* | LC |
| Ferruginoius duck | *Aythya nyroca* | NT |
| White-headed duck | *Oxyura leucocephala* | EN |
| Osprey | *Pandion haliaetus* | LC |
| Little tern | *Sterna albifrons* | LC |
| Stone-curlew | *Burhinus oedicnemus* | LC |
| Collared pratincole | *Glareola pratincola* | LC |
| Glossy ibis | *Plegadis falcinellus* | LC |
| Short-toed eagle | *Circaetus gallicus* | LC |
| Booted eagle | *Hieraaetus pennatus* | LC |
| Pallas's fish eagle | *Haliaeetus leucoryphus* | VU |
| White-tailed eagle | *Haliaeetus albicilla* | LC |
| Imperial eagle | *Aquila heliaca* | VU |
| Golden eagle | *Aquila chrysaetos* | LC |
| Lesser kestrel | *Falco naumanni* | VU |
| Common crane | *Grus grus* | LC |
| Houbara bustard | *Chlamydotis undulata* | VU |
| Black-bellied sandgrouse | *Pterocles orientalis* | LC |
| Eastern stock dove | *Columba eversmanni* | VU |
| Roller | *Coracias garrulus* | NT |
| *Mammals* | | |
| Marbeled polecat | *Vormela peregusna* | VU |
| Gray wolf | *Canis lupus* | LC |
| Goitered gazelle | *Gazella subgutturosa* | VU |
| Pale pygmy jerboa* | *Salpingotus pallidus* | |

Pale pygmy jerboa* added by authors as it is in the Red Book of Kazakhstan.

### *Fish fauna*

Several expeditions were carried out to investigate the fish diversity of Lake Balkhash and the Ile River starting in the first half of the 19th century (Mamilov, 2008). There were only five indigenous fish species in the lake: *Schizothorax pseudaksaiensis* (a cyprinid fish species), *Nemacheilus strauchi* (a stone loach species), *Schizothorax argentatus*, *Perca schrenkii* (a perch species), and *Nemacheilus labiatus* of which the latter three are endemic to Lake Balkhash (Abrosov, 1973). During the 20th century, the following species were introduced either into the lake or into the Ile River: *Acipenser nudiventris* (ship sturgeon), *Leuciscus leuciscus* (common dace), *Barbus brachycephalus* (Caspian barbel), *Abramis brama orientalis* (subspecies of common bream), *C. carpio aralensis* (subspecies of common carp), *Lucioperca lucioperca* (pikeperch), *Silurus glanis* (wels catfish), *Pseudorasbora parva* (stone moroko), *Pseudaspius leptocephalus* (redfin), *Hemiculter leucisculus* (wild carp or sharpbelly), *Perccottus glehni* (Chinese sleeper or Amur sleeper), *Rhinogobius similis* (Amur goby), *Stizostedion lucioperca* (zander), *Aspius aspius* (asp), *Chondrostoma nasus* (common nase), *Leuciscus lindbergi*, and *Rutilus rutilus* (common roach) (Abrosov, 1973; Petr, 1992). In 1972, 98% of commercial catches consisted of alien species, while the indigenous represented only two percent (Petr, 1992). The amount of pikeperch, roach, and to a lesser degree of bream and wels catfish declined due to over-fishing (Mitrofanov and Petr, 1998).

### *Reptiles and Amphibians*

Reptiles are represented by 19 species: steppe tortoise (*Agrionemys horsfieldii*), twelve species of lizards, and six species of snakes (Ramsar Convention, 2012) that mostly live in the dune areas inside or bordering the delta. Only five species are found in the coastal and wetland habitats: the lizards *Eremias velox* and *Eremias scripta*, the water snakes *Natrix tessellata* and *Natrix natrix*, and the rat snake *Elaphe dione* (Ramsar Convention, 2012). According to Nurtazin and Eszhanov (2012), the number of several species that were common before decreased significantly such as the agamid lizards *Trapelus sanguinolentus* and *Phrynocephalus guttatus*. The amphibian fauna includes the toad *Bufo pewzowi* and the frog *Rana ridibunda*, while *Rana asiatica* was once present but is now extinct (Sultanova et al., 2012).

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*Birds*

The avifauna of the Ile Delta and South Balkhash consist of 284 bird species from 53 families and 17 orders (Sultanova et al., 2012). Among them, 150 species are nesting birds, such as *Pelecanus onocrotalus* (white pelican), *Pelecanus crispus* (Dalmatian pelican), *Platalea leucorodia* (Eurasian spoonbill), *Cygnus cygnus* (whooper swan), *Aythya nyroca* (ferruginous duck), *Oxyura leucocephala* (white-headed duck), *Haliaeetus albicilla* (white-tailed eagle), *Grus grus* (common crane), *Pterocles orientalis* (black-bellied sandgrouse), *Columba eversmanni* (yellow-eyed pigeon), *Bubo bubo* (eagle-owl), *Dendrocopos leucopterus* (white-winged woodpecker), *Podoces panderi ileensis* (subspecies of Turkestan groundjay), *Parus bokharensis* (Turkistan tit), and *Passer ammodendri* (saxaul sparrow) (Berezovikov and Zhatkanbaev, 2002; Ramsar Convention, 2012; Sultanova et al., 2012).

In 2007, more than 70,000 birds were counted in the lower reaches of the Karatal River (Solokha, 2008; Ramsar Convention, 2012). Eight bird species which nest in or migrate through the Ile Delta and the southern part of Lake Balkhash have more than 1% of their global population in the Ile Delta and the lower reaches of the Karatal River (Solokha, 2008): *Anas platyrhynchos* (mallard), *Netta rufina* (red-crested pochard), *Aythya ferina* (common pochard), *Bucephala clangula* (common goldeneye), *Fulica atra* (Eurasian coot), *P. crispus* (Dalmatian pelican), *P. onocrotalus* (white pelican), and *Phalacrocorax carbo* (great cormorant). Of the 56 bird species which are listed as endangered in the Red List of Kazakhstan, 33 live in the Ile Delta and Lake Balkhash (Sultanova et al., 2012). With the desiccation of the Aral Sea, many birds lost a major habitat in Central Asia, for example pelicans (*P. crispus* and *P. onocrotalus*) ceased to nest in the Aral Sea but breed in the Ile Delta (Morimoto et al., 2005, 2008). The population of the dalmatian pelican in the Ile Delta has decreased from 900 pairs nesting in 1984–1993 to 500 pairs in 2005–2006 (Berezovikov and Zhatkanbayev, 2002; Morimoto et al., 2008; Ramsar Convention, 2012). However, the population of the white-tailed eagle (*H. albicilla*) in the Ile Delta increased from 40–43 pairs in 1996–1998 to 45–50 pairs in 2004–2007 (Zhatkanbaev, 2011). The Ile Delta is also the habitat for the biggest populations of ferruginous duck (*A. nyroca*) in Central Asia and yellow-eyed pigeon (*C. eversmanni*) in Kazakhstan (Sultanova et al., 2012).

*Mammals*

In the Ile Delta and southern part of Lake Balkhash, there are 39 species of mammals. The following three species are listed as endangered in the Red List of Kazakhstan (Table 2): *Vormela peregusna* (marbled polecat), *Gazella subgutturosa* (goitered gazelle), and *Salpingotus pallidus* (pale pygmy jerboa) (Sultanova et al., 2012).

Most mammal species live in the dunes surrounding the delta or in the riparian forests, meadow vegetation, or shrub vegetation. The six jerboa species (*Allactaga elater*, *Stylodipus telum*, *Dipus sagitta*, *Eremodipus lichtensteini*, *Salpingotus pallidus*, *Cricetulus migratorius*), the three jird species (*Meriones tamariscinus*, *Meriones libycus* and *Meriones meridianus*), and the tolai hare (*Lepus tolai*) inhabit sand dunes and the alluvial plains. The squirrel species *Spermophilopsis leptodactylus* and *Spermophilus erythrogenus* are found in the alluvial plains, too. The mouse and vole species *Arvicola terrestris*, *Mus musculus*, and *Apodemus sylvaticus* as well as muskrat (*Ondatra zibethicus*) were common in the delta, but today due to habitat loss their population has declined. In 1935, 818 individuals of muskrat were successfully introduced in the Ile Delta (Abrosov, 1973). A decade later, 54,800 muskrats were counted and trapped, but the changes of the water level during the 1970s due to the Kapchagay Reservoir destroyed their habitat and decreased their number (Abrosov, 1973; UNDP, 2004) and trapping no longer occurs. However, muskrats are apparently again quite common now (Nurtazin and Eszhanov, 2012). The great gerbil (*Rhombomys opimus*) occurs throughout Almaty Province.

Among the cloven-hoofed mammals, the most common species are *Sus scrofa* (wild boar), *Capreolus pygargus* (Siberian roe deer), and *G. subgutturosa* (goitered gazelle) (Ramsar Convention, 2012). These animal species feed in the reed beds as long as they are not too deep. Before the middle of the 20th century, the abundant deer, gazelles, and wild boars in the Ile Delta was the main prey for the Caspian or Turanian tiger (*Panthera tigris virgata*), which was recorded in the delta until 1948 (Bragin, 2009). The main reasons for its extinction were loss of reed bed and Tugai forest habitats due to fires and conversion to pastures and croplands. The WWF has proposed to reintroduce the amur tiger, as the closest relative to the previously extinct Caspian tiger, in the Ile Delta and southern region of Lake Balkhash (Jungius et al., 2009).

## Threats for the conservation of vegetation, fauna, and biodiversity

The threats to the conservation of vegetation, fauna, and biodiversity of the Ile Delta and southern Lake Balkhash are discussed firstly as those with currently ongoing impacts and secondly as those very likely to have impacts in the future (Table 3).

Today, fires are the major threat for the reed beds, meadow vegetation, parts of the Tugai forests, and parts of the shrub vegetation and their associated fauna. Fires are ignited by local people, mainly in reed beds but also in small stands of Tugai forests and shrub vegetation with reed as undergrowth, in order to remove dead biomass and thus enhance the productivity of *P. australis* as fodder. Such fires are ignited mostly during winter and early spring, but some during summer, too, and often become uncontrolled (Hirschelmann, 2014; Jungius et al., 2009). Fire causes the vegetation composition to shift to species-poor *P. australis* stands and destroys the habitat for animals (mainly mammals and birds), especially when ignited after onset of the growing season.

As described earlier, after 1988 the runoff into the Ile Delta and Lake Balkhash increased and reached levels comparable to those before the Kapchagay Reservoir started to be filled. Subsequently the reed bed and meadow area also enlarged during the 1990s (Thevs et al., 2014). Furthermore, livestock numbers decreased considerably after independence of Kazakhstan. Therefore, currently overgrazing is not a threat. Still, most of the meadows and reed beds, when not submerged, are grazed at least occasionally (Hirschelmann, 2014). The presence of herders limits the habitat for animal species, especially for large mammals, e.g. *G. subgutturosa*, and for birds.

In contrast to the reed beds, the *H. aphyllum* shrub vegetation is largely degraded. *H. aphyllum* is used as fuel wood by local people and is traded as very valuable charcoal as far as to the cities of Almaty and Astana (Buras et al., 2012). Logging of *H. aphyllum* affects also large mammals, which feed in that shrub vegetation, especially, when disturbed in the reed bed and meadow areas. Furthermore, the soil under the *H. aphyllum* vegetation becomes exposed to wind erosion, when *H. aphyllum* is logged (Michael-Succow-Foundation, 2011).

The fish fauna has been altered considerably due to the introduction of alien fish species (Petr, 1992; Mitrofanov and Petr, 1998). Fishing is an important income source for the local people in the lower delta and along the shoreline of Lake Balkhash (Piechottka, 2015). The annual fish catch peaked in 1941 with 18,650 tons/yr and stabilized in the 1980s with around 11,000 tons/yr, which is far higher than an estimated sustainable catch of around 7000 tons/yr (Mitrofanov and Petr, 1998). Therefore, over-fishing is a danger for fish stocks and fish biodiversity in the Ile Delta and Lake Balkhash (Piechottka, 2015).

Heavy metals were found in the tissues and muscles of several fishes, for instance, high levels of copper (0.92–0.98 mg/kg) in the muscles of the common roach *R. rutilus* and nickel (0.7 mg/kg) in the muscles of pikeperch (*S. lucioperca*) (Asylbekova et al., 2011). Isaeva et al. (2012) reported accumulation of nickel, cobalt, and manganese in plants of the Ile Delta.

Today, the discharge of the Ile River into the delta is as high as in the late 1980s. Whether such high discharge rates will persist in the near

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**Table 3**
Threats for biodiversity in the Ile Delta and southern Balkhash Lake.

| Threat | Impacts | Cause |
|---|---|---|
| *Current threats* | | |
| Fire | • Reed beds, Tugai forests, and shrub vegetation partly burned down.<br>• Shrinking habitat for animals. | • Ignited by local herders. Fires often get out of control. |
| Logging (fuel wood collection) | • Degradation of *Haloxylon aphyllum* shrub vegetation. | • Fuel wood collection by local people. |
| Overfishing | • Shrinking fish populations. | • Unregulated fishing. |
| Grazing | • Disturbance of other animals, mainly mammals and birds. | • Animal herding by local people. |
| Possible threats | | |
| Reduced runoff of Ile River | • Shrinking surface waters and dropping groundwater levels.<br>• Dropping water level of Lake Balkhash.<br>• Shrinking reed beds and Tugai forests, water stress for and changing species composition of natural vegetation.<br>• Reduced productivity of vegetation, especially reed.<br>• Shrinking habitat for animals. | • Increasing areas under agriculture upstream of the Ile Delta in China and Kazakhstan.<br>• Water transfer from the Ile River catchment in Xinjiang, China.<br>• Climate change, i.e. reduced glacier volume in the headwater region |
| Overgrazing | • Degradation of vegetation.<br>• Shrinking habitat for animals (e.g. space for mammals and birds). | • Increasing demand for animal products. |
| Water pollution | • Accumulation of heavy metals in plants and aquatic fauna. | • Emissions due to mining at the lake.<br>• Water pollution from China. |

future is doubtful. The area of irrigated agriculture has increased in the Chinese and the Kazakh part of the Ile Balkhash Basin (see above). Against the background of rising food prices (http://faostat3.fao.org/home/E), it is uncertain whether that trend will stop soon. Stone (2012) expects decreasing discharge into the Ile Delta. Climate change is expected to reduce the flow of rivers in Central Asia, as glacier melt comprises a significant part of their runoff (Bliss et al., 2014). Such a decrease of the discharge of the Ile River into the Ile Delta would be a major threat for the vegetation, fauna, and biodiversity of the delta, because most of the plant species depend on groundwater for their water supply. Groundwater is recharged from the surface waters in the delta. During the 1970s and 1980s, the Ile Delta experienced reduced discharge as the Kapchagay Reservoir was being filled. During that time, the area of open waters and reed beds as well as riparian forests shrank, from 1974 to 1985, the area of open water in the delta shrank from 1209 $km^2$ to 354 $km^2$ (Kipshakbaev and Abdrasilov, 1994). Degradation of reed beds and meadow vegetation through the mid-1980s resulted in a reduction of pasture grounds by two thirds compared to 1970. People responded by grazing their animals more in the riparian forests, which lead to enhanced degradation of that ecosystem mainly due to inhibited recruitment of the tree species and destruction of the herb layer (Petr, 1992).

The fish species*A. brama orientalis*, *A. aspius*, *C. carpio aralensis*, and *S. glanis* spawn in the reed beds of the Ile Delta (Abrosov, 1973) so that decreased discharges with smaller reed beds as a result would impact those fish species. For *C. carpio aralensis*, Kenzhebekov et al. (2011) showed a positive correlation of its population with river runoff.

If livestock numbers increase, e.g. due to increasing meat prices, the reed beds and meadow vegetation, as most important grazing lands, are could be threatened by over-grazing (Hirschelmann, 2014). Thus, the habitat would shrink for animal species, especially large mammal species, e.g. *G. subgutturosa* and also of birds.

## Conclusions and research gaps

The most important current threats for the vegetation, fauna, and biodiversity of the Ile Delta and southern Lake Balkhash (Table 3) are fires, logging of *H. aphyllum* shrub vegetation, overfishing, and grazing. A decreasing discharge of the Ile River into Lake Balkhash most likely will be the major future threat. Additionally, overgrazing is a possible threat.

A major knowledge gap is that the number of fires and their extent is not documented and the number of mammal and bird species that are impacted is unknown. The amount of *H. aphyllum* wood that is logged from the delta is not recorded and its regrowth rates and annual biomass increments are not well known; these factors need careful investigation, in order to fix upper limits of *H. aphyllum* harvest. Research about the impact of the fishery on the fish fauna has been very limited and the status and dynamics of fish populations are not well known. Further research is needed, in order to formulate fishing quotas that can ensure sustainable fish populations. In this context, the significance of reed beds and surface waters in different parts of the delta for spawning must be better understood.

A decreasing discharge of the Ile River into Lake Balkhash most likely will be the major threat until end of this century due to climate change and increasing water consumption by agriculture along the Ile River (cf. Sections 2 and 7). This impact of climate change on the Ile River's runoff needs further research, as the extent to which glaciers change and the associated runoff will decrease differs between river basins (Bolch et al., 2012). In order to project the discharge into the Ile Delta for the near future, estimates of water consumption by land use are needed, too. The impacts of reduced discharges of the Ili River on the distribution of surface waters and groundwater levels in the delta is a core issue, for which a hydrological model must be built. The groundwater levels are a major driver for the distribution of vegetation types and habitats as well as the productivity of that particular vegetation. Such a hydrological model, coupled with the knowledge about site conditions required by different plant species, would provide estimates about the distribution of vegetation types under a range of possible future discharge scenarios for the Ile River.

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