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Master of Science, Major Nachhaltigkeitswissenschaften – Sustainability Science

The influence of water shortage on birds at the Ili Delta in Kazakhstan

Master's Degree Thesis

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Contents

Abstract

The Ili Delta in Kazakhstan is an important ecosystem that offers crucial wetland habitats for several bird species. However, the Ili River, the Ili Delta and the Balkhash Lake are suffering from water shortage due to climate change and human activities. The desertification of the Aral Sea, an obvious point of comparison to the Balkhash region, also involved the degradation of wetland habitats and the related loss of many bird species relying on these habitats. Therefore, water shortage at the Ili Delta may also be the reason for the loss of wetland habitats and bird species. In this study, bird species numbers, species abundances as well as bird diversity at different habitats in the Ili Delta were examined. There are many habitat types provided by the Ili Delta, for example reed bed vegetation, Tugay forest, bare soil floodplains along rivers and steppe. The results of this study showed that the central delta region with habitats of submerged reed vegetation showed the highest number of bird species and the greatest diversity. Threatened bird species at the Ili Delta were also observed only in these wetland habitats. Steppe habitats showed the lowest numbers of bird species and the lowest bird diversity. In general, all habitats at the Ili Delta are important for the ecosystem and essential for the bird species that depend on them for their survival. With expansion of arid steppe habitats due to water shortage, however, previous wetland habitats may be lost. Moreover, bird species that depend on these wetland habitats may also be lost. Therefore, protective measures for the Balkhash region in general and the wetland habitats at the Ili Delta and its distinct avifauna in particular are urgently needed.

Introduction

Today, climate change causes enormous alterations to ecosystems worldwide (Cretaux et al. 2013, Schlüter et al. 2013, Unger-Shayesteh et al. 2013). Amongst, the major climatic changes are elevation in temperature and decrease in water availability (IPCC 2014). Consequently, arid landscapes, in particular, are suffering increasingly from water shortage (Schlüter et al. 2013, Unger-Shayesteh 2013, Cirella and Zerbe 2014). The resulting uncertainty and reduction of water availability, then, lead to a loss of wetland habitats especially in arid landscapes (Micklin and Aladin 2008, Conrad et al. 2013, Unger-Shayesteh 2013, Cirella and Zerbe 2014). Additionally, human activities such as irrigation of agricultural areas adjacent to the wetland habitats and alterations of river courses have lasting influences and cause declines of wetland habitats (Thevs 2005, Micklin and Aladin 2008, Dostay et al. 2012, Cretaux et al. 2013). These habitats are crucially important in many ways, but predominantly they serve as bird habitats (Kreuzberg-Mukhina 2006, Yerokhov 2006, Schielzeth et al. 2008). Wetland habitats are essential as breeding habitats for waterfowl and flyway stopover sites for migratory birds including species relevant for the typical regions (Yerokhov 2006, Schielzeth et al. 2008, Li et al. 2011). As Kazakhstan is landlocked and located far from any ocean, inland wetland habitats are particularly important in this country (Czudek 2006, Yerokhov 2006, Cirella and Zerbe 2014). Various regions in Kazakhstan are recognized as migratory staging sites for birds, such as the Tengiz–Korgalzhyn region (Czudek 2006, Kreuzberg-Mukhina 2006, Yerokhov 2006, Schielzeth et al. 2008, Fig. 1).[1] Synonymously, the Ili Delta at the Balkhash Lake in southeast Kazakhstan is another wetland

Figure 1: Overview map of Kazakhstan as a landlocked country and the important wetland sites of the Tengiz-Korgalzhyn region, the Balkhash Lake and the Aral Sea.

ecosystem and an important site for both breeding birds and migratory birds (Kreuzberg 2005, Yerokhov 2006, Khairbek and Bragin 2012, Fig. 1). But in the last 40 years, the Balkhash Lake have been undergoing tremendous changes due to climate change and human activities (Yerokhov 2006, Khairbek and Bragin 2012).

[1] In Europe, a comparable example would be the Wadden Sea, one of the most important bird breeding and migratory stopover sites (Wolff 1983, Vauk et al. 1989).

Habitats at the Ili Delta

Since 2009, the Ili Delta region has been listed as a Ramsar Wetland site[2], because it offers habitats for breeding and migratory bird species, including rare examples (Khairbek and Bragin 2012). Below the different habitat types at the Ili Delta are shown. The shoreline of the lake and the delta includes huge reed communities, which offer refuges for several bird and fish species (Aladin und Plotnikov 1993, Khairbek and Bragin 2012, Cirella and Zerbe 2014). Reeds (*Phragmites australis*) grow throughout the Ili Delta, in many different habitats, because reeds are adapted to different conditions of water availability (Thevs et al. 2007). For instance, in the central Ili Delta region, very many tall reeds which grow from submerged stems can be found in the narrow necks where water moves between the wider parts of the delta (Khairbek and Bragin 2012). Reeds growing on dry land rather than in the lake are harvested to some extent and used as cattle feed (Thevs 2011, Cirella and Zerbe 2014). Along the Ili River, on its floodplains, grow Tugay forests (Aladin and Plotnikov 1993, Thevs 2005). Tugay forests are species-rich vegetation communities of trees, bushes and tall grasses which grow along rivers in deltas (Thevs 2005, Micklin 2007). Above all, the Asian Tugay forest is home to the cottonwood (*Populus*) and willow (*Salix*) tree species, the shrub species *Tamarix,* and again, the reed *Phragmites australis* (Thevs 2005, Dostay 2007, Micklin 2007, Thevs et al. 2011). Farther away from the riverside, where ground water levels and water availability is not suitable for wetland vegetation, the main habitat is steppe (Thevs 2005, Schielzeth et al. 2008). Steppe is very arid, and supports species such as *Tamarix* and Saxaul that can adapt to the dryness (Thevs 2005, Dostay 2007). Thus, if water availability decreases in wetlands, the reed beds and the Tugay forest dry out and convert to steppe vegetation. However, for the moment, the Ili Delta remains a wetland area, whose different vegetation types provide specific habitats for a broad range of bird species and it is these different habitats and species diversity that make the Ili Delta such an unusual and important ecosystem (Kreuzberg-Mukhina 2006).

Wetlands as important habitats for birds

In general, Asian deltas provide habitats such as wetlands with Tugay forest and reed communities, which are indispensable for breeding and migratory bird species (Thevs 2005, Micklin 2007, Blümel 2013). But these habitats are disappearing, due to water shortage caused by reduced inflow from main rivers and the subsequent reduction of water levels at lakes (Kreuzberg-Mukhina 2006, Schlüter et al. 2013). For example, before the desertification of the Aral Sea in Central Asia, the riparian species rich Tugay forests provided habitats for more than 300 species of birds (Micklin 2007). These forests have,

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[2] The Convention on Wetlands, called the Ramsar Convention, is an intergovernmental treaty that provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources (Source: http://www.ramsar.org/).

however, declined by more than 85%, and as a result, the number of bird species has also decreased (Saab 1999, Schmiegelow and Mönkkönen 2002, Thevs et al. 2011). Reed communities in wetlands represent prime habitats for breeding, and they are also important flyway stopover sites for migratory birds which include several endangered species (Yerokhov 2006, Micklin 2007, Cirella and Zerbe 2014). 319 bird species lived in the river delta at the Aral Sea before the desertification, starting around 1960 (Micklin 2007). Subsequently in 2005, only 160 species were observed (Micklin and Aladin 2008). According to the Ramsar Wetland site report by Khairbek and Bragin (2012), the Ili Delta harbours 25 threatened bird species, while eight of them use the delta wetlands as nesting sites. But as the bird species loss at the Aral Sea shows, these threatened and also other bird species at the Ili Delta are endangered by the water shortage.

Plants that are better adapted to more arid conditions and salty soil such as xerophytes and halophytes, respectively, appear in wetland habitats that are increasingly affected by desertification (Micklin 2007, Blümel 2013). Consequently, bird communities are changing by adapting to the new vegetative habitats (Kreuzberg 2005, Carrillo et al. 2007). Regarding the Aral Sea desertification, the wetland habitats have been lost and its previous area was recolonized by steppe vegetation (Kreuzberg-Mukhina 2006, Yerokhov 2006). The area around the Balkhash Lake and especially the Ili Delta likewise provides crucial habitats with similar vegetation by comparison with the Aral Sea. Therefore, bird species at the Ili Delta are similarly threatened as compared to the Aral Sea. Overall, the collapse of the distinct wetland ecosystem at the Ili Delta would have a dramatic impact on the importance for the Balkhash region, as in the following a more detailed consideration of similarities between the Aral Sea and the Balkhash Lake shows (Aladin and Plotnikov 1993, Saab 1999, Kreuzberg 2005, Yerokhov 2006, Bai et al. 2011, Thevs et al. 2011).

Desertification of the Aral Sea

The well-known case of the Aral Sea desertification is comparable to the water shortage at the Balkhash Lake. Looking at the history of the Aral Sea may give an idea of the future development of the Balkhash Lake (Christiansen and Schöner 2004, Kreuzberg 2005, Yerokhov 2006, Micklin and Aladin 2008, Bai et al. 2012, Blümel 2013, Cirella and Zerbe 2014). The Aral Sea partially lies in the west of Kazakhstan in a generally arid landscape (Cretaux et al. 2013, Fig. 1). Before it began to shrink drastically in 1960, it was the fourth largest lake in the world, covering an area of 67 000 km² (Micklin 2007, Micklin and Aladin 2008, Cretaux et al. 2013). Among the main causes of the water shortage at the Aral Sea are both global climate change and resulting regional landscape changes (Cretaux et al. 2013, Schlüter et al. 2013). Due to the arid and dry climate around the Aral Sea, evaporation was always high (Micklin 2007). An increase in temperature and reduced precipitation due to climate change further increased evaporation (Hagg et al. 2013). Moreover, water extraction from the main inflow rivers of the Aral Sea for irrigation of agricultural areas led to extreme reductions of the lake and delta areas (Cretaux et al. 2013, Mannig et al. 2013, Schlüter et al. 2013). The Amu Darya and Syr Darya rivers are the main inflows and have accounted for 80% of the total water of the Aral Sea (Cretaux et al. 2013). But since the construction of water reservoirs along the Amu Darya and the Syr Darya, water shortage has intensified at the Aral Sea (Kreuzberg-Mukhina 2006, Cretaux et al. 2013). Thus, these changes of climate change and irrigation development have disturbed the balance between water inflow and loss through evaporation (Micklin 2007, Micklin and Aladin 2008, Bai et al. 2012, Unger-Shayesteh et al. 2013). As a result, since 1960, the water level of the Aral Sea has fallen 23 m, its area shrunk by 74% and the volume decreased 90% (Aladin and Plotnikov 1993, Micklin 2007). Today, the Aral Sea is separated into two water bodies due to the extreme water shortage, and therefore, the Aral Sea lost its status as an important habitat for waterfowl and other species (Micklin 2007, Cretaux et al. 2013).

As mentioned above, it is helpful to consider similarities and differences between the Aral Sea and the Balkhash Lake to get a more detailed impression of the future of the Balkhash Lake. Both lakes partially belong to Kazakhstan and are surrounded by an arid landscape (Cretaux et al. 2013). Both lakes are saline lakes (Aladin and Plotnikov 1993) due to the dry climate and the related high evaporation rates (Micklin 2007, Hwang et al. 2011, Guo and Xia 2014). A great amount of the water coming through the main rivers feeding the Aral Sea and the Balkhash Lake has been diverted for irrigation (Dostay 2007, Schlüter et al. 2013). Furthermore, along these rivers, water reservoirs were constructed, and they have significantly reduced water levels in the rivers, deltas and the lakes (Kezer and Matsuyama 2006, Cretaux et al. 2013).

At the Amu Darya delta at the Aral Sea, 2 600 lakes were present in the early 1960s. But in 1985, the number of lakes has declined to 400 lakes due to the desertification of the Aral Sea (Kreuzberg-Mukhina 2006). If the Ili Delta, with its small lakes and river branches, were to lose 85% of its water the results would be very similar to the desertification of the Aral Sea. In general, water shortage at the Aral Sea region has had a major impact on climatic, ecological, economic and social conditions (Kreuzberg-Mukhina 2006), which may be imminent at the Balkhash region as well.

Study area

I conducted my study at the Ili Delta (45°02ˈ - 46°38ˈN, 74°04ˈ - 75°41ˈE) in the southeast of Kazakhstan. The Ili Delta is formed at the estuary where the Ili River flows into the Balkhash Lake. Today, the Ili Delta has a size of about 8 000 km^2 and it is, therefore, one of the biggest deltas with perennial water throughflow in Central Asia (Kreuzberg 2005, Dostay

2007, Khairbek and Bragin 2012). The source of the Ili River, the sole feeder of the Ili Delta, is in Xinjiang in China (Christiansen and Schöner 2004, Guo and Xia 2014). About 70 to 80% of the water in the Balkhash Lake comes from the Ili River (Aladin and Plotnikov 1993, Dostay et al. 2012). Other inflows are the Karatal, Lepsy, Aksu and Ayaguz rivers, which all feed the eastern part of the Balkhash Lake (Aladin and Plotnikov 1993, cf. Fig. 3). The Balkhash Lake is about 600 km long and its width varies from 5 to 70 km (Aladin and Plotnikov 1993, Guo and Xia 2014). It is comparably shallow, the deepest point measuring only 26 m (Kreuzberg 2005, Guo and Xia 2014). The average depth of the lake is 6 m (Christiansen and Schöner 2004, Hwang et al. 2011, Guo and Xia 2014). Due to the continental arid climate in southeast Kazakhstan, evaporation around the Balkhash Lake is particularly high measuring more than 1000 mm anually (Aladin and Plotnikov 1993, Hwang et al. 2011, Dostay et al. 2012, Guo and Xia 2014, Mannig et al. 2013, Fig. 2). Annual precipitation in the area is low, at about 150 mm annually (Aladin and Plotnikov 1993, Christiansen and Schöner 2004, Fig. 2). In addition to low rainfall and high evaporation, a great amount of water is extracted from the Ili River before it reaches the Balkhash Lake, because agriculture in the surrounding dry areas requires much water for irrigation (Kezer and Matsuyama 2006, Cirella and Zerbe 2014). In the 1980s, 70% of the area around the Balkhash Lake was used for agriculture (Dostay 2007). Moreover, in 1970 the Kapchagay Reservoir was built and filled with water from the Ili River. Afterwards, from 1970 to 1985 significant changes in the amount of water in the Ili Delta were observed (Aladin and Plotnikov 1993, Dostay et al. 2012, Hwang et al. 2011). Such observations show that irrigation and water drainage for the Kapchagay Reservoir have caused water shortages in the Ili Delta and the Balkhash Lake over the last 45 years (Dostay 2007, Dostay et al. 2012). Furthermore, other studies have also show climate change in Central Asia and around the Balkhash area in particular (Mannig et al. 2013). Over the last 100 years temperature and precipitation have in fact increased (Guo and Xia 2014), but due to higher evaporation and other factors, the Balkhash area has suffered from water shortages overall (Feng et al. 2013, Mannig et al. 2013). Despite differences in river water flows due to seasonal and yearly variations, it is clear that the water flow through the Ili River and into the Balkhash Lake is falling overall (Christiansen and Schöner 2004, Dostay et al. 2012). As a result, the unique wetland ecosystems at the Ili Delta in Kazakhstan are critically endangered due to water

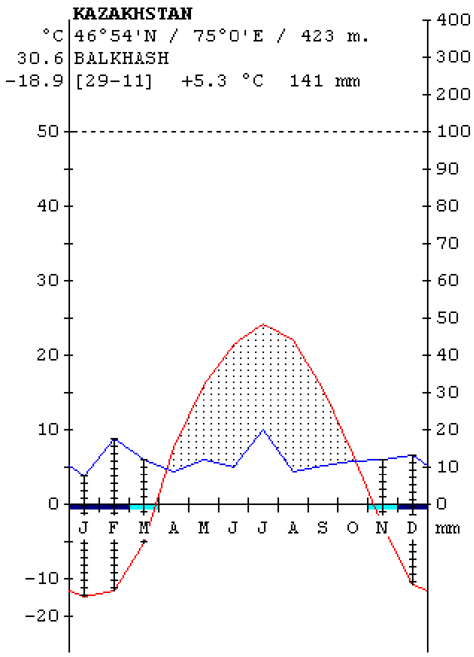

Figure 2: Climate diagram for the Balkhash area in Kazakhstan (Source: www.global-bioclimatics.org/plot/ka-alkh.htm)

shortage resulting from climatic changes and anthropogenic impacts (Kreuzberg 2005, Dostay et al. 2012, Khairbek and Bragin 2012). The scenarios modelled by Christiansen and Schöner (2004) show potential results of the alteration of the Balkhash Lake if it continues more or less severely (Fig. 3).

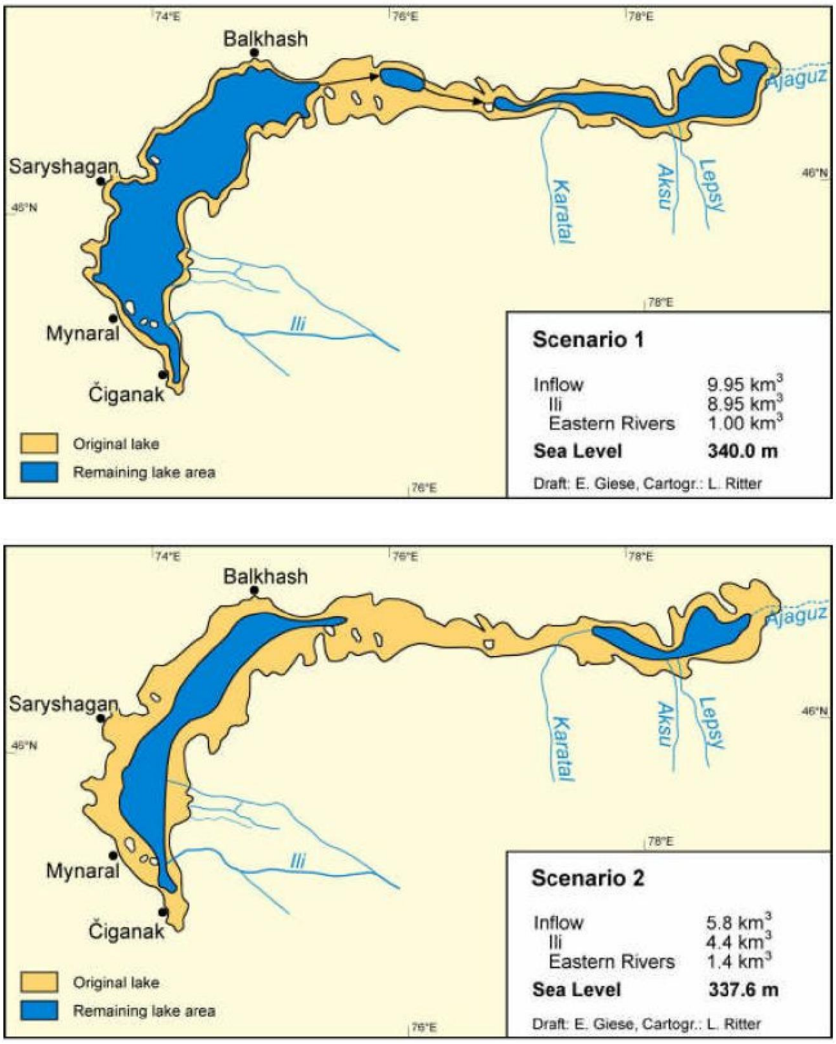

Figure 3: Two senarios for water shortage at the Balkhash Lake. Normally, the Balkhash Lake requires an average inflow of about 15 km^3/year from the Ili River. To date, the Balkhash Lake receives 11.8 km^3/year. Scenario 1 and 2 show the remaining lake area with a reduced water inflow of 34% and 61% respectively (Christiansen and Schöner 2004).

Due to the already occurring water shortage at the Ili Delta, and given the even more drastic predictions of increasingly reduced water levels, there may be fewer suitable habitats for wetland vegetation such as reeds and Tugay forest (Christiansen and Schöner 2004, Thevs 2005, Khairbek and Bragin 2012). In turn, steppe vegetation may expand into these areas that are falling dry and wetland habitats may be lost. Bird species adapted to the degrading landscape may lose their habitat, and resultant bird populations decline. Therefore, it is important to ascertain how many bird species live in different habitats. High species numbers implicate redundant species which are important for resilience and reorganization of ecosystems after disturbances (Folke 2006). It is also important to ascertain which species prefer particular habitats. Then, it is possible to consider the changing composition of bird species at the Ili Delta that are mostly affected by habitat loss due to water shortage. Merely few bird species may adjust to the new habitat diversification and other species may immigrate (Schmiegelow and Mönkkönen 2002). Concurrently, wetland habitat degradation and species loss are affected by several ecological effects (Saab 1999, Howell et al. 2000, Kallimanis et al. 2008). Altogether, the Ili Delta, the wetland habitats and the related bird species are threatened due to water shortage. Therefore, in this research I hypothesize that, water shortage at the Ili Delta in Kazakhstan causes a loss of bird species, a change in bird community composition and a decrease in bird diversity.

I address the following research questions for my study of the influence of water shortage on bird populations at the Ili Delta in Kazakhstan:

(1) How many bird species live in the different wetland and steppe habitats at the Ili Delta?

(2) Are there Red List bird species occurring at the Ili Delta?

(3) Which bird species are specific to the different habitats at the Ili Delta?

(4) Which bird species may disappear with growing habitat degradation due to desertification at the Ili Delta?

Methods

Study design

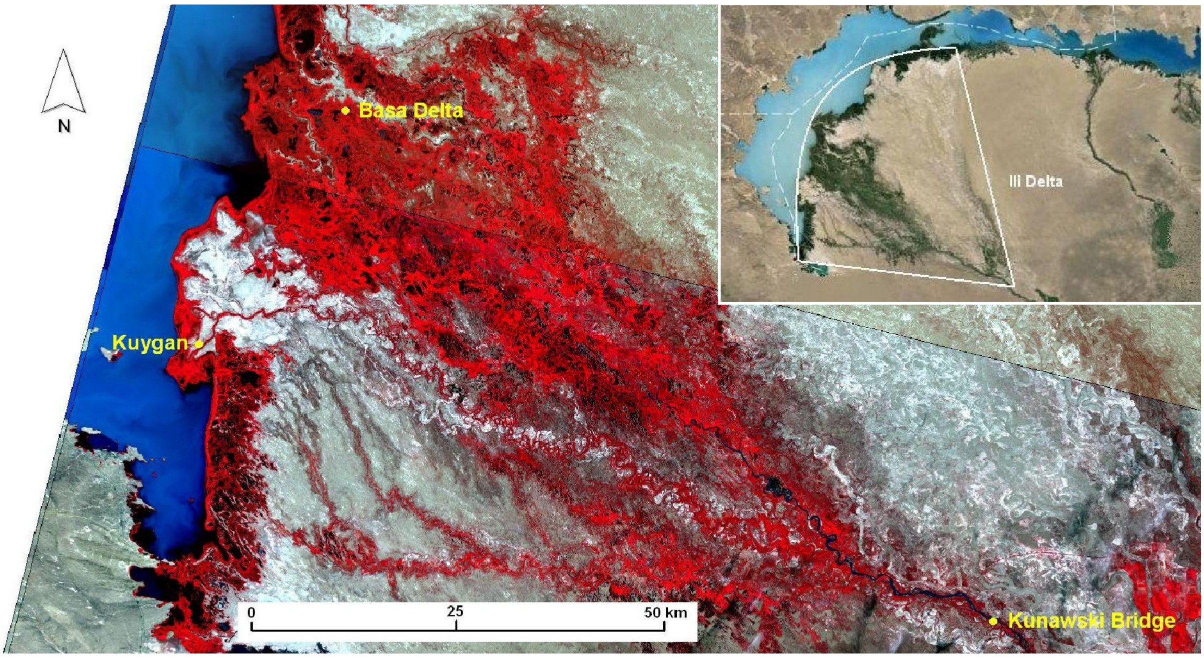

Figure 4: Study sites at the Ili Delta in Kazakhstan are Kuygan, Kunawski Bridge and Basa Delta.

To monitor the bird community across the different habitat types, I established three study sites, each with four plots, which were located within the Ili Delta (Fig. 4). The plots at each study site differed in water availability, as plots measured different distances to the water bodies, and resultant they consisted of different vegetation types (Tab. 1). Each plot was 100 ha, through which I established an observation route of about 3 km, using the methods of line mapping (Mitschke et al. 2005, Südbeck and Weick 2005, cf. *Bird observations*).

My first study site was in Kuygan, which is a small fishing village at the end of the Ili Delta. The village lies directly on the Ili River and is very close to the Balkhash Lake (Fig. 4). The four plots in Kuygan were divided as follows: Two plots were located in the steppe around the village with respective distances of 500 and 1 500 m to the river. My observation routes in these steppe plots did, however, come near to branches of the river with reed communities. Thus, neither of these plots was a pure steppe landscape, although the many branches of the river delta make it difficult to avoiding it completely. So, it is important that the vegetation types of steppe and reed were in fact mixed in these two plots. The vegetation of the third plot was reed, which stems were partially

Table 1: Summary of plot division in my study design.

Plot	Study site	Vegetation type	Visits
11	Kuygan	steppe and reeds	4
12		submerged reeds	4
13		steppe and reeds	4
14		Reeds	4
21	Kunawski Bridge	Tugay forest	3
22		river stream	3
23		river stream	3
24		steppe	3
31	Basa Delta	submerged reeds	4
32		submerged reeds	4
33		submerged reeds	4
34		Reeds	4

submerged and which I observed from a boat on the river. The fourth plot at Kuygan constituted reeds growing on dry land (Summary of plot division see table 1).

The second study site was at the Kunawski Bridge, at the beginning of the Ili Delta. Here, the Ili River begins to divide due to backwater and forms the Ili Delta. One of the plots here was located in Tugay forest, which in total only covered an area of about 400 ha. The second and third plots were directly in the stream of the Ili River. These two plots included habitats of open river water, bare soil floodplains, reed communities and scattered shrubs as well as sandy dunes on islands. The fourth plot at the Kunawski Bridge was located in steppe vegetation 1 km from the river.

The third study site was in the central delta region, named Basa Delta study site. Thus, all four plots in this Basa Delta study site were conducted in reed beds. In three of the Basa Delta plots I used a boat for observations of partially submerged reed stems. The fourth plot here was on an island with reed beds partially growing on dry land, and partially submerged reed stems (Tab. 1).

I visited all water plots, when necessary, using an inflatable two-person canoe and was accompanied by a second person who paddled while I observed. For my first observations at each of the Basa Delta plots, the second person in the boat was an ornithologist who introduced me to the regional bird fauna. After that, the second person in the boat did not help with my observations. Altogether I visited the plots to make bird observations approximately every 19 days during the study period (with the shortest repetition interval being 13 days, and the longest 31 days).

Bird observations

I conducted my study from June to August 2014. I did bird observations in each study site four times, except for the study site at the Kunawski Bridge, which I visited three times for lack of time (Tab. 1). On each visit to each plot I did bird observations for approximately three hours starting shortly after sunrise varying from 5:30 to 6:15 a.m. during the study. So, in total, I conducted 9 to 12 hours of bird observations at every plot, at the Kunawski Bridge study site and the other two study sites respectively. Additionally, I recorded the weather situation, noting cloud cover (as 0-33%, 33-66% or 66-100%), occurrence of rain (none, drizzle, shower) and wind strength (still, calm, strong). I only conducted observations in suitable weather conditions (no persistent or heavy rain and no strong wind). The date, time of sunrise, observation starting time and exact duration of observations were also recorded. I performed the observations using binoculars. Audio recording and photographing enabled me to record species where identification was uncertain and confirmed species identity later on. For every bird observed, visually or aurally, I documented the species, the number of individuals, the behaviour and the observation time. Particularly important were observations of breeding behaviours including breeding on an occupied nest, territorial disputes, or as singing or display, for example, as grading breeding behaviours allowed estimation of the importance of the plot and habitat for the recorded bird species as suggested by the method of line mapping (Südbeck and Weick 2005). Other behaviours noted included movements such as flying, arriving or circling. Birds that merely flew over a plot were recorded, but were not given as much importance as resident bird species. But overflying birds were still important for characterizing the study site (rather than the smaller plot) and the surrounding environment (Saab 1999). More than one behaviour manner for one observed individual was possible. Furthermore, I tracked my observation walks with a GPS device so as to be able to retrace the exact positions of my bird recordings, combining the time of bird recording and the GPS point at the same time. For instance, this was especially necessary in Kuygan (plots 11 and 13) to differentiate birds recorded in steppe or reed vegetation. Distinguishing the vegetation types for bird recordings was also very important at the Kunawski Bridge (plots 22 and 23), as the island vegetation changed over comparably small spatial scales.

Statistical analysis

All statistical analyses were conducted in R 2.12.1 (R Development Core Team 2008). The first statistical analysis tested the normal distributions of species and individual numbers with the Kolmogorov-Smirnov Test. This analysis showed that species and individual numbers were not normally distributed, so I then performed Fligner Tests to confirm correlation tests with ONEWAY ANOVAs. Thus, correlations of species and of individual numbers with other parameters were identified by ONEWAY ANOVAs and subsequent POST HOC TUKEY tests (confidence level = 0.95). The Wilcox Test was used to verify the correlations. I checked for correlations between numbers of species and of individual and factors that might influence these numbers, such as observation duration, weather parameters and even who my companion in the boat was. Further, I tested for significant differences in the numbers of species and of individuals between the three study sites as well as between all twelve plots. To indicate diversity the Shannon index was calculated with the software package Vegan (Oksanen et al. 2015). The Shannon index was used here to indicate diversity, because this index gives higher weight to rare species in comparison to other diversity indices such as the common Simpson index (DeJong 1975). Furthermore, an ordination was generated by the software package Vegan. Ordinations allowed more specific comparison of different habitat types in my study as they calculated community similarities across different plots (Oksanen 2013, Oksanen et al. 2015). For endangered species, using the package Bipartite, I created a network between bird species and plots of their occurrence and the assigned vegetation type (Dormann et al. 2008).

Results

Table 2 shows the results of correlation tests on the data of this study. The first two rows of table 2 show the results for tests to exclude effects of sampling extent. No differences of observation durations between the three study site and the twelve plots are revealed (Tab. 2). Further, observation durations did not correlate with bird species numbers or with individual numbers (Tab. 2, rows 3-4). Possible influences from the weather situation on species numbers and individual numbers (abundances) could also be excluded (Tab. 2, rows 5-10). The first bird observations in Basa Delta, which were conducted in company of the ornithologist, counted significantly higher species numbers compared to the subsequent observations when the second person was not an ornithologist (Tab. 2, rows 11-12).

Table 2: Correlations tested with ONEWAY ANOVA and Tukey HSD (significance level = 0.95).

Correlation		p-value	R^2
Sites	Duration	> 0.05	0.03
Plots	Duration	> 0.05	- 0.15
Duration	Species	> 0.05	- 0.02
Duration	Individuals	> 0.05	< 0.01
Cloud cover	Species	> 0.05	0.01
Cloud cover	Individuals	> 0.05	0.07
Wind	Species	> 0.05	0.15
Wind	Individuals	> 0.05	0.06
Rain	Species	> 0.05	- 0.01
Rain	Individuals	> 0.05	- 0.02
Company	Species	< 0.01	0.42
Company	Individuals	> 0.05	0.07

Bird species numbers and abundances in different habitats

Over 124 observation hours, I observed 88 bird species and 16 432 individuals. The most frequently observed bird species was the Bearded Reedling (*Panurus biarmicus*, 2 358 individuals). The Great Reed Warbler (*Acrocephalus arundinaceus*, 1 078 individuals) was the second most abundant species. The Basa Delta study site had the highest bird species numbers across the study sites, harbouring 66 species across all four plots and all four observation times (Tab. 3). In Kuygan, 62 species were observed in total. Kunawski Bridge had the lowest number of observed species, with 58 species observed in three observation rounds over the field work period. The average species numbers across all four plots at the Kunawski Bridge were also the lowest in comparison to the other study sites (Tab. 3).

Table 3: Species numbers per observation, in total and average for every plot.

Site	Plot	Obs 1	Obs 2	Obs 3	Obs 4	Total	Average
Kuygan	11	26	20	23	24	41	23.25
	12	26	26	29	35	52	29.00
	13	21	22	22	23	38	22.00
	14	18	21	27	24	39	22.50
Kunawski Bridge	21	12	18	18	NA	27	16.00
	22	22	21	18	NA	34	20.33
	23	16	21	18	NA	31	18.33
	24	14	11	22	NA	29	15.67
Basa Delta	31	33	23	27	22	41	26.25
	32	34	27	26	25	46	28.00
	33	37	27	29	23	42	29.00
	34	40	30	33	32	54	33.75

In total, plot 24 at Kunawski Bridge had the lowest and plot 34 in the Basa Delta study site the highest average species numbers. Plot 12 in Kuygan showed relatively high species numbers similar to the plots in Basa Delta (Tab. 3 and Fig. 5). Correlation tests showed significant differences in average species numbers across all three study sites (Tab. 4). Species abundances also differed significantly between all three study sites (Tab. 4). Comparably to the basic species numbers in all plots, the Shannon index used to indicate diversity showed slight differences in the ranking of plots in terms of species numbers for the respective habitats at each plot (cf. Fig. 5 and Fig. 6). However, both species numbers and the diversity index showed that plot 24 at the Kunawski Bridge had the lowest species numbers and diversity. The other three plots at the Kunawski Bridge also had the next lowest species numbers and diversity. According to the Shannon index, the highest diversities were at all four Basa Delta plots and at plot 12 in Kuygan, the latter having greatest diversity of all (Fig. 6). The ordination method revealed various similarities and dissimilarities in bird communities across all the twelve plots and respective habitats (Fig. 7).

Table 4: Differences in bird species and individual numbers between the study sites of Kuygan, Kunawski Bridge and Basa Delta, respectively. Correlations were tested with ONEWAY ANOVA and Tukey HSD (significance level = 0.95).

Correlation			p-value
Species numbers	Kuygan	Kunawski Bridge	> 0.001
	Kunawski Bridge	Basa Delta	> 0.001
	Basa Delta	Kuygan	> 0.001
Individual numbers	Kuygan	Kunawski Bridge	> 0.001
	Kunawski Bridge	Basa Delta	> 0.001
	Basa Delta	Kuygan	> 0.001

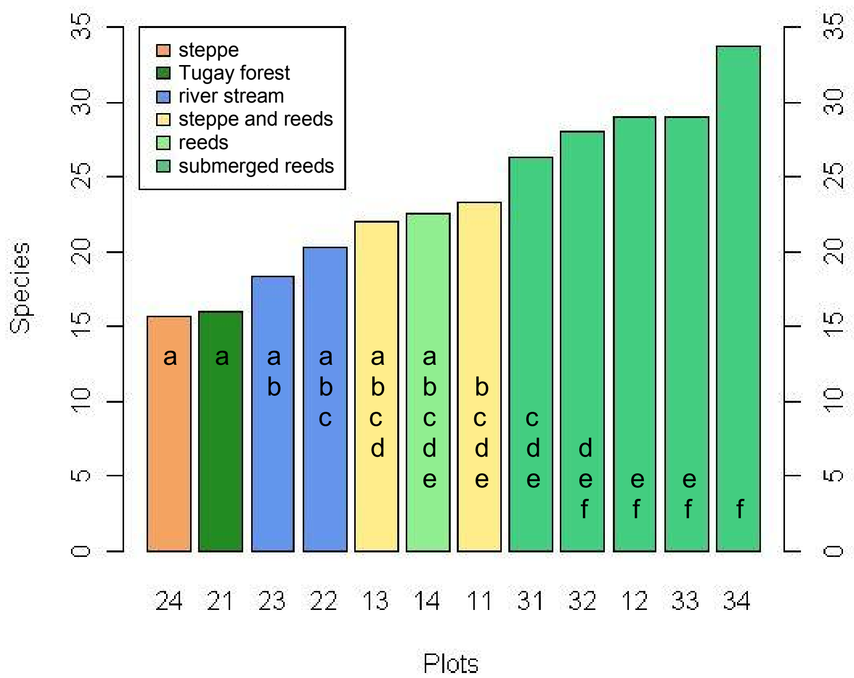

Figure 5: Amount of bird species in the different plots and for respective habitat types. Plots that are marked with the same letters are not significantly different to each other. Tested with ONEWAY ANOVA and Tukey HSD (sign. level = 0.5).

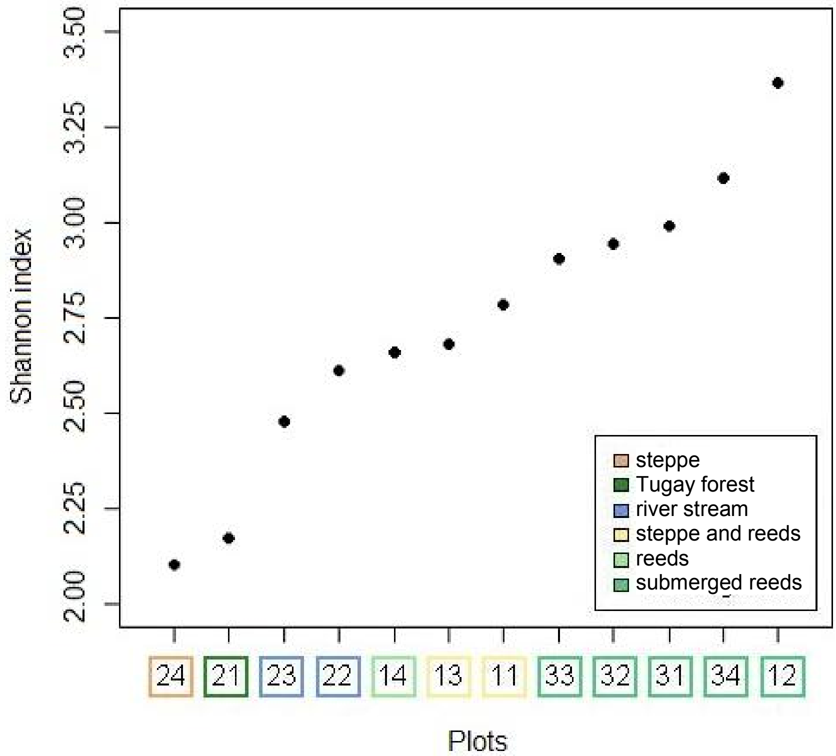

Figure 6: Diversity index calculated with the Shannon index for different plots and respective habitats.

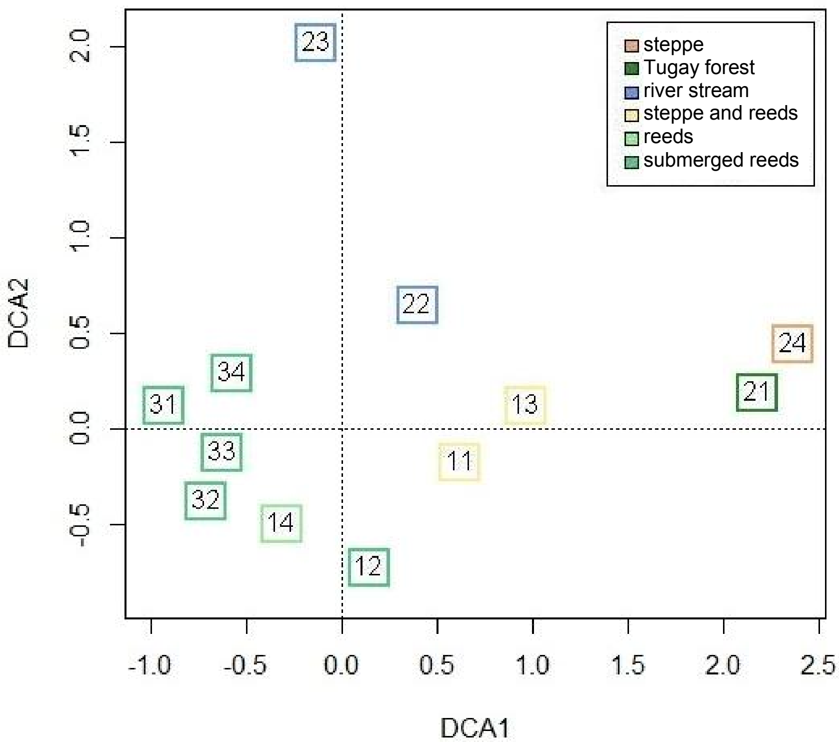

Figure 7: Ordination showing habitat-specific bird communities across the twelve different plots and respecitive habitats. The ordination represented species numbers.

Threatened bird species at the Ili Delta

I observed seven of the 25 threatened bird species that live in the Ili Delta according to the Ramsar Wetland site report by Khairbek and Bragin (2012). These species included the White Pelican (*Pelecanus onocrotalus*), the Dalmatian Pelican (*Pelecanus crispus*), the Eurasian Spoonbill (*Platalea leucorodia*), the Whooper Swan (*Cygnus cygnus*), the Ferruginous Duck (*Aythya nyroca*), the Little Tern (*Sterna albifrons*) and the European Roller (*Coracias garrulus*). These threatened species were only observed in wetland habitats. In regard to more specific habitats, threatened bird species were observed in plots with submerged reed vegetation (plots 12, 31, 32, 33 and 34), in reed communities growing on dry land but still close to branching off river arms (plot 14 and reed habitat in plot 11) as well as directly at the water stream at the Kunawski Bridge (plots 22 and 23, Fig. 8). All of the seven bird species were observed at the study site Basa Delta. The three species European Roller (*Coracias garrulus*), Little Tern (*Sterna albifrons*) and Ferruginous Duck (*Aythya nyroca*) were also observed in the Kunawski Bridge plots. The Ferruginous Duck was also observed at the plot 11 in Kuygan. All other species were only observed in the submerged reed plots in the study sites of Basa Delta and Kuygan (Fig. 8). Thus, the two threatened species Dalmatian Pelican (*Pelecanus crispus*) and Eurasian Spoonbill (*Platalea leucorodia*) were only observed in the Basa Delta study site. As noted above, the plots in the Basa Delta study site harboured the highest bird species numbers overall, and likewise Basa Delta also had the highest abundances of threatened bird species. The Little Tern was observed the most frequently of the threatened bird species (Fig. 8).

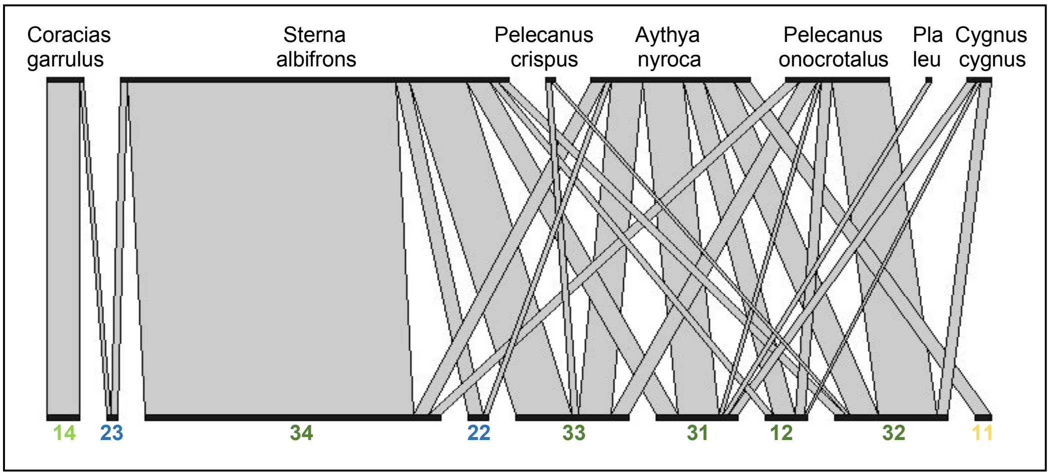

Figure 8: Occurrence of threatened bird species (top) in different plots (below) and respective habitats (blue = river stream, yellow = steppe & reeds, light green = reeds and middle green = submerged reeds).

Observations of bird species in different habitats

Certain bird species typically coexist in different habitats due to their sharing habitat requirements. There now follows information on the occurrence of bird species in the different plots across the study presented with regard to the different habitats accommodating those species. Some bird species in the study distinctively occupied the open water areas of shallow and small water bodies (Tab. 5). Other bird species favoured water bodies surrounded by dense reed or grass vegetation (Fig. 9), including several duck species (cf. Tab. 5). Most ducks were seen at the Basa Delta study site, usually in large accumulations. Many ducks were also observed in Kuygan. But in Kuygan, ducks mostly flew over the plots. One plausible possibility to explain this is that the study site of Kuygan was very close to the Balkhash Lake with an open water area and the ducks were flying to and from this open water (cf. Fig. 4). Additionally, terns and gulls occurred numerously in the Basa Delta study site and at the river plots (plots 22 and 23) at the Kunawski Bridge, but were also observed flying over Kuygan. Additional bird species were also distinctive of reed vegetation directly at the water body where reed stems are partially submerged (Fig. 9), although these are too many to list here (but cf. Tab. 5). Many bird species rely on reed vegetation in wetlands but open water bodies alone do not represent a customary habitat for them. In this study, various warblers were of this type (Tab. 5). These warbler species appeared numerously in the Basa Delta study site, all of which had reed vegetation, and in the Kuygan plots where dense reed vegetation was present.

Figure 9: Submerged reeds (*Phragmites australis*) in the central delta region of Basa Delta with small shallow water bodies.

Some species were found along rivers and at lakes but preferred bare soil floodplains (Tab. 5). These species were seen in the Basa Delta plots and along the river at the Kunawski Bridge where riverbeds and sandy edges alongside lakes, as well as reed vegetation for cover and breeding places, were present. Shorebirds such as sandpipers and rails were observed directly at the water's edge or in submerged reeds. They were found at sandbanks along the river (plots 22 and 23, Fig. 10) or hiding in dense reeds (plots 11, 12 and 34). Sandpipers and rails were thus distinctive of open areas like muddy and sandy shores along a river or small water bodies surrounded by reeds.

Figure 10: Riverbank with bare soil floodplains along the river stream at the study site of Kunawski Bridge.

Figure 11: Tugay forest with cottonwood (*Populus*) and the *Tamarix* as shrub species.

Tugay forest accommodated many bird species such as the Azure Tit (*Cyanistes cyanus*) and the Turkestan Tit (*Parus bokharensis*), which were observed here with highest abundances. The Tugay forest habitat was very near to steppe vegetation in plot 21 at the Kunawski Bridge, with transitional vegetation between the two habitats. *Tamarix* and Saxaul shrubs are present in the Tugay forest habitat but likewise in the steppe vegetation (Fig. 11). Therefore, in plot 21 at the Kunawski Bridge, bird species were spotted in the Tugay forest that are normally found in steppe vegetation habitats, such as the Red-headed Bunting (*Emberiza bruniceps*) and the White-winged Woodpecker (*Dendrocopos leucopterus*). Other bird species were observed in riparian forests as well as the steppe, although one or the other of these habitats might be their more preferred (cf. Tab. 5, Fig. 7).

The steppe habitat accommodated many different bird species. Birds of prey were most often observed in dry habitats such as steppes (Fig. 12). These predator species were observed in all twelve plots across this study, but most of different predator species were observed in the steppe habitat, and this is where their highest abundances were also found. The steppe habitat is quite varied, and bird species that prefer scattered shrubs in an open and dry habitat as is typical of some parts of the steppe were observed here (cf. Tab. 5). But further bird species favoured well-vegetated steppe. Other bird species preferred small non-steppe areas such as reed beds surrounded by dry steppe, such as the two harrier bird species *Circus aeruginosus* and *Circus pygargus.* These two harrier species were observed in almost all plots, but with the highest abundances they were observed to live in open wetlands with reed communities that lay within steppes (plots 11, 13, 14, 22, 32 and 33).

Figure 12: Habitat of steppe with *Tamarix* and Saxaul shrubs as well as dunes in Kuygan.

Several bird species were very adaptable and occurred in almost all plots. The Grey Heron (*Ardea cinera*) was seen in each plot, although it was observed overflying some of these plots. The Carrion Crow (*Corvus corone*), the Eurasian Magpie (*Pica pica*), the Common Cuckoo (*Cuculus canorus*), as well as the Yellow Wagtail (*Motacilla feldegg*) were observed in each plot across the study with comparatively the same individual numbers in each plot.

Table 5: Bird species observed in this study with scientific and English name. The threatened species are coloured red. The respective habitats are coloured as follows: red = steppe, dark green = Tugay forest, blue = river stream, yellow = steppe & reeds, light green = reeds and middle green = submerged reeds.

Scientific name	English name	Habitat in this study
Accipiter badius	Shikra	steppe
Acrocephalus agricola	Paddyfield Warbler	reed vegetation in wetlands
Acrocephalus arundinaceus	Great Reed Warbler	reed vegetation in wetlands
Acrocephalus melanopogan	Moustached Warbler	reed vegetation in wetlands
Actitis hypoleucos	Common Sandpiper	bare soil floodplains
Alcedo atthis	Common Kingfisher	Steep sandy faces at rivers used for nesting
Anas platyrhynchos	Mallard	open water areas of shallow and small waterbodies
Anas querquedula	Garganey	water bodies surrounded by dense reed vegetation
Anas strepera	Gadwall	water bodies surrounded by dense reed vegetation
Anthus spec	Pipits	steppe
Ardea cinera	Grey Heron	water bodies surrounded by dense reed vegetation
Ardea purpurea	Purple Heron	submerged reeds
Aythya nyroca	Ferruginous Duck	water bodies surrounded by dense reed vegetation
Botaurus stellaris	Eurasian Bittern	submerged reeds
Buteo rufinus	Long-legged Buzzard	steppe
Calidris ferruginea	Curlew Sandpiper	bare soil floodplains
Calidris temminckii	Temminck's Stint	bare soil floodplains
Casmerodius albus	Great Egret	open water areas of shallow and small waterbodies
Cettia cettia	Cetti's Warbler	reed vegetation in wetlands
Charadrius dubius	Little Ringed Plover	bare soil floodplains
Chlidonias niger	Black Tern	water bodies surrounded by dense reed vegetation
Chroicocephalus ridibundus	Black-headed Gull	open water areas of shallow and small waterbodies
Circus aeruginosus	Western Marsh Harrier	steppe
Circus pygargus	Montagu's Harrier	steppe
Columba livia	Common Pigeon	in bridge structures
Coracias garrulus	European Roller	scattered trees in reed vegetation
Corvus corone	Carrion Crow	seen in all plots
Cuculus canorus	Common Cuckoo	seen in all plots
Cyanistes cyanus	Azure Tit	Tugay forest
Cygnus cygnus	Whooper Swan	open water areas of shallow and small waterbodies
Dendrocopos leucopterus	White-winged Woodpecker	Tugay forest and steppe
Emberiza bruniceps	Red-headed Bunting	steppe
Emberiza schoeniculus	Common Reed Bunting	reed vegetation in wetlands
Falco subbuteo	Eurasian Hobby	steppe
Falco tinnunculus	Common Kestrel	steppe
Fulica atra	Eurasian Coots	open water areas of shallow and small waterbodies
Gallinula chloropus	Common Moorhen	submerged reeds
Haematopus ostralegus	Eurasian Oystercatcher	bare soil floodplains
Himantopus himantopus	Black-winged Stilt	bare soil floodplains
Hirundo rustica	Barn Swallow	water bodies surrounded by dense reed vegetation
Iduna rama	Sykes's Warbler	steppe
Ixobrychus minutus	Little Bittern	submerged reeds
Lanius phoenicuroides	Turkestan Shrike	Tugay forest and steppe
Larus cachinnans	Caspian Gull	open water areas of shallow and small waterbodies
Locustella luscinioides	Savi's Warbler	reed vegetation in wetlands
Luscinia luscinia	Thrush Nightingale	Tugay forest and steppe
Luscinia svecica	Bluethroat	shrubs in reed vegetation
Melanocorypha calandra	Calandra Lark	steppe
Merops persicus	Blue-cheeked Bee-eater	reed vegetation in wetlands

Table 5: Continued.

Scientific name	English name	Habitat in this study
Milvus migrans	Black Kite	steppe
Motacilla citreola	Citrine Wagtail	steppe
Motacilla feldegg	Yellow Wagtail	steppe
Motacilla flava	Yellow Wagtail	steppe
Motacilla personata	Masked Wagtail	steppe
Netta rufina	Red-crested Pochard	water bodies surrounded by dense reed vegetation
Oenanthe isabellina	Isabelline Wheatear	steppe
Oriolus oriolus	Eurasian Golden Oriole	scattered trees in reed vegetation
Panurus biarmicus	Bearded Reedling	reed vegetation in wetlands
Parus bokharensis	Turkestan Tit	Tugay forest
Passer ammodendri	Saxaul Sparrow	Tugay forest and steppe
Passer montanus	Tree Sparrow	small trees in reed vegetation
Pelecanus crispus	Dalmatian Pelican	open water areas of shallow and small waterbodies
Pelecanus onocrotalus	Great White Pelican	open water areas of shallow and small waterbodies
Phalacrocorax carbo	Great Cormorant	open water areas of shallow and small waterbodies
Phalacrocorax pygmeus	Pygmy Cormorant	open water areas of shallow and small waterbodies
Phasianus colchicus	Common Pheasant	in reed vegetation
Phylloscopus trochiloides	Greenish Warbler	steppe
Pica pica	Eurasian Magpie	seen in all plots
Platalea leucorodia	Eurasian Spoonbill	submerged reeds
Podiceps cristatus	Great Crested Grebe	open water areas of shallow and small waterbodies
Porzana pusilla	Baillon's Crake	submerged reeds
Rallus aquaticus	Water Rail	submerged reeds
Recurvirostra avosetta	Pied Avocet	bare soil floodplains
Remiz pendulinus	Eurasian Penduline Tit	reed vegetation in wetlands
Saxicola maurus	Siberian Stonechat	shrubs in reed and steppe vegetation
Sterna albifrons	Little Tern	water bodies surrounded by dense reed vegetation
Sterna hirundo	Common Tern	water bodies surrounded by dense reed vegetation
Sturnus vulgaris	Common Starling	open habitats with reed vegetation
Sylvia deserti	African Desert Warbler	steppe
Sylvia halimodendri	Lesser Whitethroat	steppe
Tringa ochropus	Green Sandpiper	bare soil floodplains
Tringa totanus	Common Redshank	bare soil floodplains
Upupa epops	Eurasian Hoopoe	trees in reed and steppe vegetation
Vanellus vanellus	Northern Lapwing	bare soil floodplains
Xenus cinereus	Terek Sandpiper	bare soil floodplains

Discussion

The results of my study at the Ili Delta clearly demonstrate the great importance of the wetland ecosystem for breeding and migrating waterbirds in the region. The Ili Delta in Kazakhstan contains a broad diversity of bird species in different habitats. However, some of these habitats, for example wetland habitats, harbour, compared to arid habitats such as steppe, more bird species (Fig. 5).

Bird species numbers in different habitats

My study emphasizes that submerged reed bed vegetation at water bodies, as they occur in the central delta region and along rivers close to the Balkhash Lake, show the highest number of bird species and the greatest diversity (Fig. 5 and Fig. 6). Therefore, these wetland habitats are crucial for the Ili Delta and the bird species that depend on these wetlands for their survival. In addition, reed vegetation growing on dry land, which is still close to water streams, showed medium values for bird species numbers and diversity. The ordination showed that all habitats with reed vegetation in this study were similar to each other with regard to bird communities (Fig. 7).

The mixed vegetation of steppe and reeds had, compared to steppe vegetation, higher species numbers. This can be explained by the fact that diverse landscapes with a mixture of different vegetation types may offer different habitat types and therefore harbour more species than monotonous landscapes (Saab 1999). Further, the composition of bird species in habitats with mixed vegetation of steppe and reeds in comparison to steppe vegetation was different (cf. Fig. 7). For these reasons, the river stream at the Kunawski Bridge study site was expected to show comparably high numbers of species and great diversity, as this habitat is characterised by heterogeneous vegetation (Saab 1999, Thevs et al. 2011). Bird species numbers and diversity were, however, low at the river stream at the Kunawski Bridge. The two plots at the river stream at the Kunawski Bridge, further, were dissimilar to each other regarding bird communities, because the vegetation types measuring small spatial scales in these habitats also differed between the two plots (Fig. 7).

Regarding Tugay forest, it was expected that compared to the numbers at other habitats, many species of bird would occur in the forest, because it is also heterogeneous and rich in plant species (Saab 1999). However, Tugay forest showed low bird species numbers. According to the hypothesis of species-area relationship, species numbers increase with larger study areas (Kallimanis et al. 2008). In this study, the habitats showed different extents, but each plot inside the different habitats had the same size of 100 ha and observations occurred for the same time, three hours. This standardisation allowed for a comparison of species numbers in different habitats. Nevertheless, different habitat types showed differences with regard to individual and thus species numbers (Kallimanis et al. 2008). As the habitat of Tugay forest at the Kunawski

Bridge study site was small in comparison to other habitats examined in the study, the numbers of individual birds as well as species were low.

The central delta region of Basa Delta is a large continuous landscape, whereas the Tugay forest and the river stream at the Kunawski Bridge study site are small and heterogeneous habitats with a large proportion of habitat edges. Therefore, in this study, the edge effect, the effect of patch size of habitats as well as the interplay of these two effects on bird species numbers should be considered for the different plots (Saab 1999, Howell et al. 2000). More species are found in areas where different habitat types are overlapping and this phenomenon has been described as edge effect (Saab 1999). Larger habitats include, however, more species, a fact that has been explained with the patch size effect (Saab 1999). Also, in small habitat fragments, reduced pairing success has been observed (Howell et al. 2000). Thus, many ecological principles may affect the number of bird species in different habitats simultaneously.

The central delta region with submerged reed vegetation showed the highest bird species numbers and the greatest diversity, and therefore they should be preserved. These reed communities are essential to secure and protect today's bird species numbers and the diversity in this wetland ecosystem at the Ili Delta. In the following section, all habitat types examined in this study and their respective importance for specific bird species are considered. The loss of bird species due to habitat degradation will also be discussed.

The importance of different habitats for specific bird species

The Ili Delta is significant because of its different habitats and the bird species that live there. The results of my study demonstrated that different bird species preferred different habitat types (Ayé et al. 2012). Nevertheless, the bird species observed at the Ili Delta are adapted to this ecosystem with its distinct composition of different habitats including large reed bed vegetation, which are of tremendous importance.

According to the Ramsar Wetland site report by Khairbek and Bragin (2012), 25 threatened bird species live in the Ili Delta and seven of these were observed in wetland habitats with reed vegetation in this study. The central delta offers an optimal habitat for threatened bird species due to its reed vegetation. It preserves these threatened species and therefore, the Ili Delta deserves protection.

The Ili Delta harboured many bird species that were not observed to the same extent at the Tengiz–Korgalzhyn region (Schielzeth et al. 2008). For instance, at the Ili Delta, the Eurasian Bittern (*Botaurus stellaris*) and Little Bittern (*Ixobrychus minutus*) were frequently observed in shallow wetlands with extensive reed beds. At the Tengiz–Korgalzhyn region in northern Kazakhstan, these bittern species were rarely seen (Schielzeth et al. 2008). This makes the Ili

Delta even more worthy of protection, because it provides habitats for species that rarely occur in other wetland sites in the same country.

According to other studies that investigated the effect of habitat structure on birds, the surrounding landscape need to be considered in addition to the delimited plot inside different habitats (Saab 1999). Overall, the wetland habitats with submerged reed bed vegetation along water bodies in the central delta region and along rivers close to the Balkhash Lake are crucial for the Ili Delta. These wetland habitats are important to secure bird species numbers and diversity at this particular delta site, but the other habitats are also significant inasmuch as other bird species showed specific preferences for these habitats. For instance, the two bird species Black-winged Stilt (*Himantopus himantopus*) and Eurasian Oystercatcher (*Haematopus ostralegus*) are regarded as specific river delta species (Ayé et al. 2012). Moreover, the combination of all habitat types currently available at the Ili Delta is necessary to secure diversity at the delta. As the results of this study showed, several bird species live in Tugay forest as well as steppe habitat (cf. Tab. 5). Some habitat types cannot be separated from each other, and the fluent transition of these habitats is essential for several species (Saab 1999, Terraube et al. 2010). But if only steppe habitats replace wetland habitats as well as the unique mixture of habitats, a great number of bird species may be lost at the Ili Delta.

In this study, steppe habitats were observed as preferred habitat for predator species. Another study on bird species in northern Kazakhstan also showed that the Montagu's Harrier preferred bushy areas in forest-steppe transition areas (Terraube et al. 2010). Other studies also focused on individual predator species, of whom most favoured steppes as habitats (Sánchez-Zapata et al. 2003, Tella et al. 2004). Further studies examined other bird species that were mostly found in steppe vegetation all over the world (Combreau et al. 1999, Laiolo and Tella 2006, Kamp et al. 2011, Pidgeon et al. 2001). At the Ili Delta, all plots mostly provided conditions preferable for predator bird species, as the delta in total is a patchy lowland and open landscape.

The survey at the Ili Delta identified some generalist bird species such as the Carrion Crow (*Corvus corone*), the Eurasian Magpie (*Pica pica*) as well as the Common Cuckoo (*Cuculus canorus*), which were observed in each plot with approximately the same individual numbers. In other avian studies, the Common Cuckoo was also very common across all habitats (Schmiegelow and Mönkkönen 2002). In general, habitat generalists are less affected than habitat specialists by changes in the landscape, because generalist species are more resilient to habitat changes (Howell et al. 2000, Jones et al. 2000). Nevertheless, these generalist species make up only a small part of all bird species observed at the Ili Delta. In general, most bird species at the Ili Delta preferred different habitat types and are dependent on these habitats.

To conclude, there are many habitat types provided by the Ili Delta. Each habitat by itself and in relationship to the surrounding habitats is important for the ecosystem and essential for the bird species there. Bird species have different requirements on habitats and therefore respond differently to habitat changes (Jones et al. 2000), and both bird species and their habitats are likely to be severely affected by water shortage.

Wetland habitat degradation and bird species loss

The wetland habitat at the Ili Delta is changing dramatically due to water shortage. The entire ecosystem is changing, because the water flow through the Ili River into the Balkhash Lake has been reduced by 66% (Christansen and Schöner 2004, Kreuzberg 2005), and because reed communities, Tugay forest and steppe are adversely affected by lower ground water levels and greater distances to the main water courses (Zerbe et al. 2010). Habitats that are highly dependent on constant availability of water, such as submerged reed communities in the central delta region, may dry out and shrink enormously (Thevs et al. 2007, Propastin 2012). Even reed communities on dry land as well as Tugay forests are more sensitive to decreasing availability of water than *Tamarix* shrubs (Thevs 2005). Therefore, the wetland habitats of submerged reed vegetation, reed communities on dry land and Tugay forest may disappear due to water shortage at the Ili Delta, and these habitats may be replaced by steppe vegetation. As a result, bird species that depend on wetland habitats may be lost (Jones et al. 2000), and the Ili Delta may lose its importance as wetland habitat for breeding and migrating waterbirds in Kazakhstan.

The habitats adjacent to the water bodies, such as reeds growing on dry land and Tugay forest, are suffering from water shortage, but they are less sensitive to water shortage than submerged reeds (Thevs 2005). In general, reeds are very adaptable, and thus, they occur at varying ground water levels and with different stem sizes (Thevs et al. 2007). Therefore, reeds and also Tugay forest habitats may be able to shift their local distribution along with the water distribution due to changes in water availability and decreasing ground water level. This successional development is also influenced by the water flow and the related changes to the river movement and is varying in time (Thevs 2005). However, the species community of reeds and of Tugay forest may recolonize bare soil floodplains along the river at the Kunawski Bridge due to succession (Thevs 2005, Thevs et al. 2008). It is possible that reed communities and Tugay forest may recolonize the area that has already been changed or even colonize a larger habitat than before. It is, however, much more likely at this point that habitats with reed communities and Tugay forest will continue to shrink, especially if the groundwater level is lowered as quickly as at the Aral Sea (Thevs et al. 2008, Zerbe et al. 2010). For bird species living in reed and Tugay forest habitats, there will be major changes to their respective habitat and possibly habitat reductions at the Ili Delta. Therefore, bird species that mostly prefer reed communities as habitat may be lost due to the degradation of wetland habitats. Bird species that are typically found in Tugay forest may also be lost, but species that prefer both Tugay forest and steppe habitats, may resort to steppe vegetation as the Tugay forest habitat shrinks due to water shortage at the Ili Delta.

Bare soil floodplains alone provide optimal feeding conditions for waders and other waterbirds that feed on riverbeds and sandy edges beside lakes, which were present at the Kunawski Bridge and the Basa Delta study site (Boere and Dodman 2010, Ten et al. 2012). Freshwater species like the Green Sandpiper (*Tringa ochropus*) and the Temminck's Stint (*Calidris temminckii*) frequently visit river floodplains for feeding. For this reason, it is very important to protect these stretches of rivers and edges beside lakes, which also provide habitats for other bird species (Boere and Dodman 2010).

Due to water shortage at the Ili Delta, steppe habitats may expend. In turn, bird species living in steppe habitat are likely to benefit from these changes. In Kuygan, the steppe habitats are very small and surrounded by the Ili River and its branches (Fig. 3). If these steppe habitats were to expand, they would harbour more species, because larger habitats normally accommodate more bird species (Saab 1999). The number of species in a given habitat depends, however, on its earlier status, that is, it matters whether the appropriate habitat was already present before it expanded or whether it changed recently (Carillo et al. 2007). As steppe vegetation fully surrounds the Ili Delta, an increase in steppe habitats due to degradation of wetland habitats may not increase bird species numbers and diversity at the Ili Delta in Kazakhstan.

Comparing the plots of steppe vegetation in Kuygan and at the Kunawski Bridge, the plots in Kuygan showed higher species numbers and higher diversity of bird species. As the steppe habitat at the Kunawski Bridge is much larger than in Kuygan, more bird species would be expected here, as suggested by the hypothesis of the species-area relationship (Kallimanis et al. 2008). The steppe habitats in Kuygan are more heterogeneous, because they are mixed with wetland vegetation, and as a result, these habitats showed more species (Saab 1999, Fig. 3). Therefore, it is desirable to protect the Ili Delta in its current status with its mixture of habitats and a large proportion of wetland habitats.

Not only wetland habitats but, according to other studies, also the landscape type of steppe has suffered in Central Asia (Sánchez-Zapata et al. 2003). All around the world, also including Kazakhstan, desert and steppe species are endangered, because steppe habitat has collapsed there (Combreau et al. 1999, Tella et al. 2004, Laiolo and Tella 2006). Moreover, steppe habitats are still more diverse in terms of bird species than agricultural habitats such as grasslands (Pigeon et al. 2001, Sánchez-Zapata et al. 2003). It is important to note here that bird species numbers are increasing in steppe because they decline in other habitats such as wetlands (Pigeon et al. 2001). Wetland habitats contained more species and a higher diversity in my study at the Ili Delta, and this area therefore should be protected, but steppe vegetation is still important (Kamp et al. 2011).

Estuarine wetland habitats with reed vegetation, Tugay forest and shrub communities build a dynamic and heterogeneous patchy landscape (Zerbe et al. 2010, Li et al. 2011). Therefore, the entire Ili Delta is very important for waterbirds and worthy of protection (Li et al. 2011). But the loss of habitats due to water shortage causes population and species losses of breeding and migrating waterbirds (Jones et al. 2000, Schmiegelow and Mönkkönen 2002). Wetland habitats with submerged reed provide living places for most bird species, but it will decrease due to water shortage at the Ili Delta and the harboured bird species will be lost. In turn, the habitat of steppe, which showed the lowest species numbers and mainly common species, will expand (Schmiegelow and Mönkkönen 2002). As a result, the bird species numbers and also the bird diversity is likely to decrease at the Ili Delta due to water shortage.

Conclusion and conservation implications

The natural estuarine wetlands at the Ili Delta are the most important habitats for waterbirds (Li et al. 2011, Dostay et al. 2012). Further loss of wetland habitat due to desertification should be prevented at the Ili Delta (Boere and Dodman 2010). As the comparison of the Balkhash Lake with the Aral Sea showed, the Balkhash Lake and the Ili Delta are adversely affected by water shortage. The consequences for the wetland ecosystem at the Ili Delta are very likely to be as dramatic as at the Aral Sea. However, the wetland habitats at the Aral Sea and Balkhash Lake basin are both regarded as very important for breeding waterbirds such as pelicans, cormorants, herons, egrets, swans and ducks (Kreuzberg-Mukhina 2006). At the wetlands at the Aral Sea, the breeding success of waterbirds has been suggested to be relatively low (Kreuzberg-Mukhina 2006). While the Dalmatian Pelican (*Pelecanus crispus*) and the Pygmy Cormorant (*Phalacracorax pygmaeus*) were still breeding in unexpected places at the Aral Sea, the overall distribution of threatened bird species declined (Kreuzberg-Mukhina 2006). To prevent the loss of threatened bird species at the Ili Delta, further habitat loss due to desertification should be stopped.

The critical situation at the Ili Delta suggests that factors such as climate change, irrigation for agriculture and the diversion of water to artificial reservoirs should be reduced or even stopped. However, social and economic aspects need to be considered when it comes to future management decisions (Cai et al. 2003). If wetlands are lost as a result of climate change, irrigation or both, equivalent habitats with similar ecological functions have to be created (Boere and Dodman 2010). In this context, the potential restorations of degraded habitats should be taken into consideration. However, restoration of estuarine wetlands in arid landscapes is difficult due to limited water resources (Cirella and Zerbe 2014). But as estuarine wetlands are very dynamic landscapes, many restoration strategies to secure bird species diversity are possible (Li et al. 2001). Another possibility to protect bird species numbers and diversity in the Ili Delta would be to alter artificial water bodies to provide attractive habitats for waterbirds. In a

study of an arid landscape in South Africa, waterbirds were observed to use many artificial wetlands (Boere and Dodman 2010). These artificial water bodies could, in contrast to the dynamic natural wetlands, provide habitats all year round (Boere and Dodman 2010).
Moreover, during my study, I observed several additional disturbance factors in the Ili Delta. The village of Kuygan, for instance, is a fishing village, and most of the people rely on fishing. Fishing practices and boat traffic on the lake and estuaries startle birds. Consequently, breeding birds may prematurely leave their breeding sites and are not able to rear their chicks (Carney and Sydeman 1999). Migratory birds may also avoid the Ili Delta as migratory stopover site due to human disturbances (Boere and Dodman 2010).
Frequent visits of tourists may have a similar effect on birds in the wetlands. In the tourist station of Basa Delta, the number of visitors arrive on the weekends, and these people visit the tourist station for recreation and fishing. Tourists are driven around by staff in motor boats. Most breeding birds that were observed in Basa Delta, such as the threatened Great White Pelican (*Pelecanus onocrotalus*), are very shy. In general, larger waterbirds are more easily disturbed than smaller waterbirds (Boere and Dodman 2010). Other nesting waterbirds that are not covering in reeds are highly visible while nesting for example the threatened Little Tern (*Sterna albifrons*) at the Kunawski Bridge and the Black-winged Stilt (*Himantopus himantopus*) in Basa Delta (Carney and Sydeman 1999). These species are even more sensitive to human disturbances. For this reason, disturbances such as fishing and tourism in Basa Delta may cause breeding birds to abandon this area and also the colony (Carney and Sydeman 1999, Boere and Dodman 2010).
Furthermore, I observed hunting of birds in Kuygan and in Basa Delta. Yerokhov (2006) criticised the hunting of duck species in Kazakhstan and pointed out that hunting of bird species is counterproductive to conservation strategies. In addition, the harvesting of reeds and stock farming are other factors disturbing and thus threatening birds. Reed communities that are growing on dry land around Kuygan and Basa Delta are harvested or occupied by cattle or horses, which may also deter birds from breeding. At the Kunawski Bridge, cattle and many horses were always seen at the study site. Protected habitats, without pressure from human intrusion, offer better conditions for bird species, especially regarding Tugay forest (Czudek 2006, Cirella und Zerbe 2014). In general, to protect bird breeding places and diversity at the Ili Delta, disturbances caused by human activities have to be reduced. In order to achieve this goal, it is necessary to reach out to the local communities and to involve them in conservation efforts.
The collaboration of both Kazakhstan and China is necessary to protect the Ili Delta because both countries are socially and economically dependent on the water of the Ili River and the Ili Delta. Both countries should act jointly to protect the Ili Delta and its distinct ecosystem (Kreuzberg 2005, Taithe 2007, Starodubtsev and Truskavetskiy Kreuzberg 2011).

My study shows the influence of water shortage on birds at the Ili Delta in Kazakhstan. Due to water shortage and subsequent wetland habitat degradation, bird species numbers and bird diversity are likely to decrease. In particular, threatened bird species may lose their preferred habitat, that is, submerged reed vegetation. The Ili Delta in Kazakhstan is an irreplaceable wetland ecosystem, and therefore, protective measures for this wetland habitat and the avifauna are urgently needed. Last but not least, future scenarios of climate change and anthropogenic disturbances should be created for the Ili Delta in order to examine the development of bird species numbers for this very important wetland ecosystem.

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Weblinks

http://www.globalbioclimatics.org/plot/ka-balkh.htm (Last retrieval. 10.02.2015)

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Appendix

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Statutory Declaration

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