Land use changes and raptor conservation in steppe habitats of Eastern Kazakhstan

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Abstract

Steppe habitats in central Asia have suffered important land use changes during this century which are similar to those that have been pointed out as the causes of the decline of steppe birds in western Europe. During June 1999 we conducted road surveys of raptors in Eastern Kazakhstan to detect specific and community responses to land use changes. We detected 11 species of raptors. Kestrels (*Falco naumanni* and *tinnunculus*) were the most common species in grasslands and agricultural landscapes, harriers (*Circus pygargus* and *macrourus*) were dominant in saline steppes and steppe eagles (*Aquila nipalensis*) were dominant in dry steppes. There were fewer species in agricultural habitats than in grassland and steppe habitats. Ground-nesting raptors were negatively affected by land use changes and four species were never detected in agricultural zones. Raptor abundance patterns differed between natural steppe habitats and human-transformed habitats, where a patchy distribution was detected. The future of raptor communities in Kazakhstan seems uncertain although the progressive abandonment of intensive agriculture may benefit species sensitive to human presence. The long-term conservation of vertebrate communities may depend upon the maintenance of ecologically and socially sustainable grazing systems.

Keywords: Steppes; Raptors; Habitat transformation; Grazing systems; Kazakhstan

1. Introduction

The response of birds to habitat changes has been a central topic in conservation biology and landscape ecology has widely centred on forest fragmentation in temperate habitats of Europe and North America (Wilcove, 1985; Saunders et al., 1991; McGarigal and McComb, 1995). More recently, ecologist have paid attention to changes in open habitats such as shrubsteppes, grasslands and extensive farming systems (Herkert, 1994; Bignal and McCracken, 1996; Pain and Pienkowski, 1997; Suárez et al., 1997; Sutter and Brigham, 1998; Ormerod and Watkinson, 2000; Wolff et al., 2001). Research on avian responses to steppe transformation has been carried out in extensive farming systems of western Europe that resemble natural grassy habitats (Goriup, 1988; Suárez et al., 1997; Blanco et al., 1998; Tella et al., 1998; Tella and Forero, 2000) where it is considered that 76% of avian species linked to natural or semi-natural Europe steppe habitats are suffering population declines (Suárez et al., 1997).

Large Old World natural steppe areas remain, however, in central Asia (mainly Kazakhstan, Mongolia and Russia) where there is little information available on the effects of land-use changes on bird communities (Bragin, 1999) although this habitat is a stronghold for globally rare raptors such as lesser kestrels (*Falco naumanni*) or imperial eagles (*Aquila heliaca*) (del Hoyo et al., 1994; Parr et al., 2000). There, large transformations in steppe and semi-desert were made during the middle of 20th century when the USSR. administration promoted the so-called "upturn of virgin lands". Thus,

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from 1954 to 1965, and even later, most parts of northern humid steppes were transformed into agricultural lands (E. Bragin, personal communication). In arid southern zones, irrigation programs transformed huge extensions of semi-desert along the Syr Darya River into intensive agriculture at high ecological cost, including a reduction in the extent of the Aral Sea and the contamination and salinization of soils and waterbeds. In Eastern and Northern Kazakhstan, large extensions of steppes and dry steppes were transformed into extensive agriculture following programs to change the nomadic way of life of Kazakh shepherds to sedentary and agricultural settlements. These changes may have also influenced the ecological processes of steppes. In spite of such transformations, the size of the country and the low human density has allowed the persistence of large steppe zones with little or no human influence. Furthermore, human population has been decreasing over the last years and some agricultural areas have undergone a recovery process into natural steppes. By 1992 the liberalization of the economy was underway, agriculture was rapidly decreasing and >50% of ploughed land in steppes had been abandoned. Furthermore, as in other Inner Asia countries, livestock had been privatized and herding collectives dismantled (Fernández-Giménez, 1999a).

In this paper we examine how land-use transformations of dry Kazakh steppes have affected the breeding community of birds of prey. Raptors are usually considered as top predators whose presence and richness indicate healthy ecosystems (see Newton, 1979; but also Rodríguez-Estrella et al., 1998). In addition, raptors can be detected with relative ease compared to more elusive organisms. Thus, indices of raptor abundance have been widely used to assess the impact of human-induced transformations within a variety of habitats, ecosystems and biomes (Burnham et al., 1990; Ellis et al., 1990; Rodríguez-Estrella et al., 1998). These indices allow us to examine if raptor abundance follows spatial patterns that can be related to a patchy or homogeneous distribution of resources. The identification of these patterns can be made through spatial autocorrelation approximations (Legendre and Legendre, 1998), a statistical approach widely employed in plant ecology but still poorly known among vertebrate ecologists (see Legendre and Fortin, 1989).

Summarizing, our specific aims were: (i) to describe the breeding raptor communities of the Kazakh steppe ecosystems; (ii) to test if raptor distribution patterns are repeated along habitats with different degrees of alteration; and (iii) to analyse the effects of steppe transformation on the abundance and composition of these communities and discuss future conservation scenarios for raptors in steppe habitats.

2. Methods

2.1. Study site

The study was conducted between 12 and 28 June 1999 in Eastern Kazakhstan (Central Asia, Fig. 1). The climate is continental, with very cold winters (when temperatures remain under 0 °C for months), and warm summers. The conditions can also be considered as arid or semiarid with annual rainfall <300 mm. The extreme temperatures and rainfall limit the growth of tree species (Walter, 1981) and landscape is dominated by steppe and semidesert plains and hills with grasses and small bushes, whereas trees are confined to foothills of large mountains (Tien Shan in the south, Altai and Alatul in the east) or around human settlements and river valleys.

We considered four different habitat types in the study area:

1. Agricultural landscapes (AGRI). The landscape is dominated by cereals and irrigated crops, managed pasturelands, cities and villages. There are also numerous herds including sheep, horses and cows. Small woods and scattered tree formations are frequent around large villages (>1000 inhabitants) and along some roads.
2. Seminatural grasslands (GRASS). Here the landscape is dominated by extensive livestock and some extensive agriculture, but villages are small with <500 inhabitants. There are many abandoned fields and degraded steppe areas.
3. Saline steppe (SAL). This habitat includes large saline steppe and marshes in the vicinity of Baljash and Alakol Lakes. Vegetation is dominated by various saline shrubs (*Sarcocornia* spp. *Scirpus* spp. *Artrocnemum* spp) and reedbeds *Phragmites* spp. with sparse trees (*Populus tremula*, *Eleagnus hortensis*).
4. Dry steppes (STEPPE). This includes large areas of natural dry steppes with little or no human presence. Trees are lacking and the vegetation is dominated by grasses and forbs (*Artemisia* spp., *Limonium* spp., *Salsola* spp., *Ephedra* spp., *Haloxylon* spp.). There are also sparse rocky outcrops.

2.2. Road counts

The surveys were conducted in June 1999: habitat 1 (504 km between Almaty and Beskol (Alakol Lake); habitat 2 (142 km between Aqtoghay and Ayaköz and closed to Zaysan Lake); habitat 3 (89 km in flood plains around Baljash and Alakol lakes) and habitat 4 (155 around Baljash Lake).

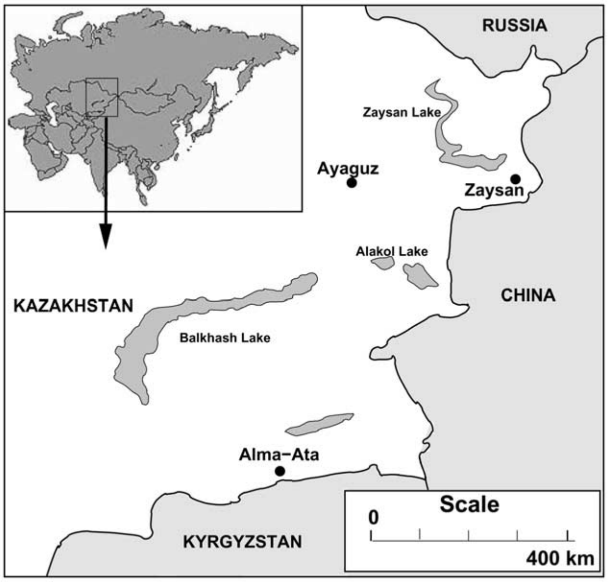

Fig. 1. Study area.

Roadside counts were done following methods widely employed in similar studies (see e.g. Fuller and Mosher, 1987; Donázar et al., 1993a,b; Travaini et al., 1995). The average driving speed was 40–50 km/h. We recorded every raptor seen and the km interval where they were observed. In a few cases it was necessary to stop the vehicle to identify the birds (Ellis et al., 1990). In this case, we did not record new birds observed during the stop. In the case of steppe eagles (*Aquila nipalensis*), we distinguished between adult and immature birds on the basis of plumage (Forsman, 1998). Finally, we also recorded the number of villages, cattle herds and susliks (*Citellus* spp., Rodentia) along each survey route for a further description of the habitat. The surveys were carried out in fine weather, without clouds and with wind velocity <20 km/h.

2.3. Data analysis

Each raptor species was assigned to one of the following nesting habitats: ground, tree, rock or rock/tree according to their breeding life histories (del Hoyo et al., 1994). The first level of analysis was done through contingency tables and χ^2-tests (Siegel, 1956) pooling the data to look for differences in the frequency of ground breeding raptors (nesting substrate accessible to predators) rock or tree-nesting species. Differences in raptor abundance, measured as birds observed per km, were tested by means of non parametric Kruskal–Wallis tests.

Second, we used Generalized Linear Models (GLMs) (Dobson, 1983; McCullagh and Nelder, 1989) to describe the abundance (raptors/km) of the most common species in the four main habitats. Each km interval of the transect was assigned to one of the four major land uses. As we registered the number of raptors detected at each km of transect, we used a Poisson distribution as error and link functions (Vincent and Haworth, 1983; Nichols, 1989; Donázar et al., 1993a,b; Sánchez-Zapata and Calvo, 1999). For GLMs we used the program STATISTIX (Analytical Software, 1992).

Finally, because of low data available on human settlements (e.g. herds or human population) we analysed spatial patterns of raptor assemblage by means of spatial autocorrelograms with Moran's Index as autocorrelation statistic (Legendre, 1993; García-Charton and Pérez-Ruzafa, 1999), using the program autocorrelation included in the "R" v.3 package (Legendre and Vaudor, 1991). For each habitat category we performed successive tests comparing similarity between pairs of sites separated by increasing distances, from 1 km (lowest distance class) to half the total length of the road census, with that obtained from pairs of sites randomly selected. Moran's index varies between $+1$ and -1 and is comparable to a Pearson correlation coefficient. Values >0 represent similarities between points greater than expected from random; those <0 representing an opposite trend. Significance of the tests were determined at two levels. First, we performed a global test by checking whether the autocorrelogram contained at least one value that was significant at the $\alpha = 0.05/n$ Bonferroni's corrected level for multiple tests (Legendre and Legendre, 1998). Second, the statistical significance of each Moran's index was examined by comparing the actual distributions whith those obtained by random. Patchy distributions would take place when autocorrelograms show a significant positive or negative peak of Moran's Index at a given distance class. Gradients are represented by significant positive values of Moran's Index at low distance classes followed by negative values (García-Charton and Pérez-Ruzafa, 1999). Due to limitations in the number of data that could be entered in the program (Legendre and Vaudor, 1991), AGRI transect was classified into sampling units of 3 and 5 km (Fig. 2a and b, respectively). For the rest of the transects the sampling unit was 1 km.

3. Results

We detected 11 species of raptors during the surveys (Table 1). The highest species richness (10 species) was reached in natural (dry and saline) steppes; grassland habitats held eight species whereas in agricultural areas it dropped to only five species. Common and lesser kestrels (*Falco tinnunculus* and *F. naumanni*, respectively) were the most abundant species in agricultural areas and seminatural grassland. Pallid and Montagu's harriers (*Circus macrourus* and *C. pygargus*, respectively) made up the bulk of raptors in saline steppe. Finally, steppe eagle (*Aquila nipalensis*) was the commonest spe-

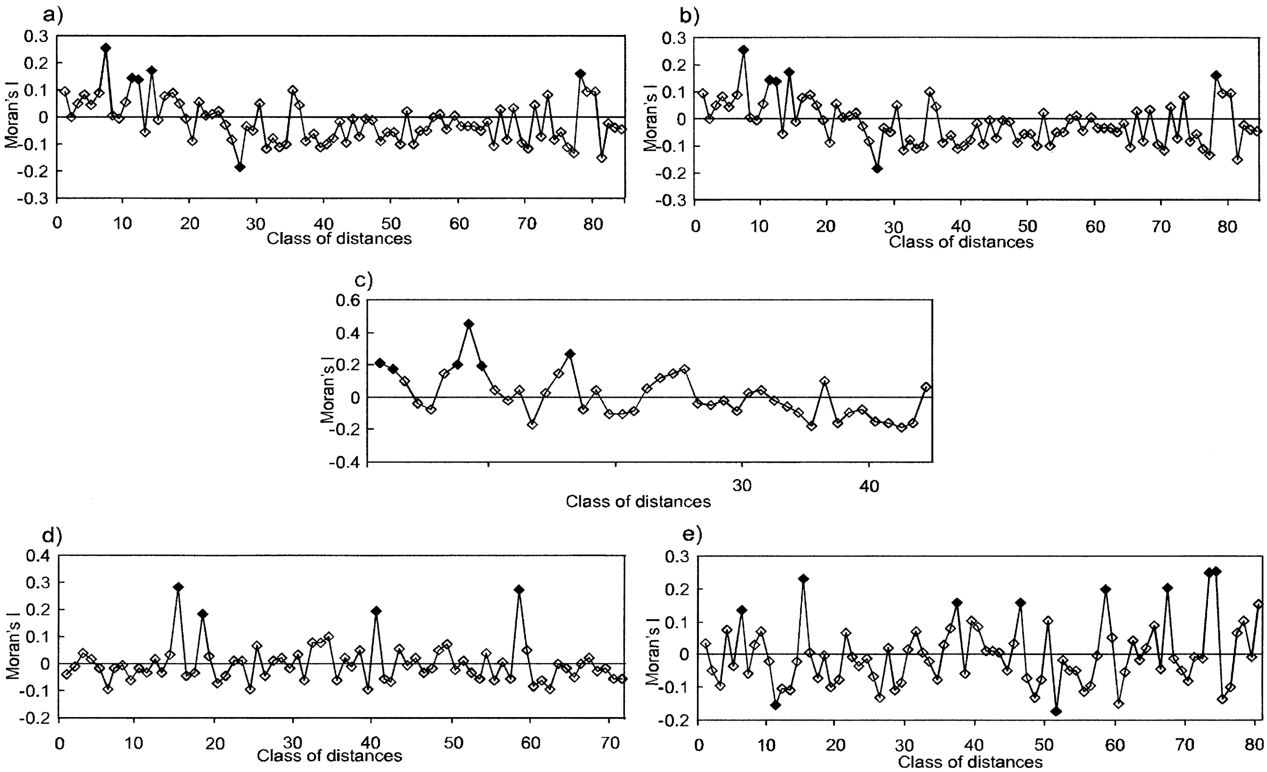

Fig. 2. Serial autocorrelation between pairs of sampling units separated by distances ranging from 1 (adjacent units) to half the length of the transects, for the total abundance of raptors in eastern Kazakhstan. (a) and (b) AGRI: highly humanized agriculture landscape (Bonferroni's correction at $\alpha=0.0003$ and $\alpha=0.0005$, respectively), (c) GRASS: extensive agriculture and grasslands (Bonferroni's correction at $\alpha=0.0006$), (d) SALINE: saline steppe and marshlands (Bonferroni's correction at $\alpha=0.0004$) and (e) STEPPE: dry steppes (Bonferroni's correction at 0.0003). Black dots: Moran's Index $P<0.05$. ** Significant autocorrelograms ($P<0.05$).

Table 1
Raptor counts (birds/100 km) in four different habitats in Eastern Kazakhstan (in brackets, number of birds observed during road counts)

Species	AGRI	GRASS	SALINE	STEPPE
Milvus migrans	2.2 (11)	–	3.4 (3)	–
Buteo rufinus	0.8 (5)	2.1 (3)	5.6 (5)	5.0 (8)
Aquila heliaca	–	–	–	0.6 (1)
Aquila nipalensis	–	3.5 (5)	1.1 (1)	11.3 (18)
Circaetus gallicus	–	–	–	1.3 (2)
Circus spp.	–	2.1 (3)	3.4 (3)	–
Circus pygargus	0.2 (1)	2.1 (3)	7.9 (7)	–
Circus macrourus	–	1.4 (2)	7.9 (7)	1.3 (2)
Falco cherrug	–	–	–	1.3 (2)
Falco subbuteo	1.2 (6)	1.4 (2)	1.1 (1)	–
Falco naumanni	2.8 (14)	22.4 (32)	–	–
Falco tinnunculus	–	9.1 (13)	3.4 (3)	1.9 (3)
Falco nau/tin	27.1 (136)	13.3 (19)	3.4 (3)	–
Total	34.5 (174)	57.3 (82)	39.3 (35)	23.1 (36)
Towns	3.0 (15)	4.9 (7)	–	–
Cattle herds	12.7 (64)	10.6 (15)	16.9 (7)	–
Citellus spp.	0.8 (4)	0.65 (1)	–	10.3 (16)

AGRI, highly humanized agriculture landscape (504 km); GRASS, extensive agriculture and grasslands (142 km); SALINE, salty steppe and marshlands (89 km); STEPPE, dry steppes (155 km).

cies in dry steppes. Around villages and more managed areas we did not find four species: steppe eagle, saker falcon (*Falco cherrug*), short-toed eagle (*Circaetus gallicus*) or pallid harrier.

Global raptor abundance was different among habitats ($H=10.96$, $P=0.0119$). The abundance of raptors was higher in seminatural grasslands and saline steppes than in agricultural and dry steppe habitats. As regards nesting habitat, we found a much higher frequency of individuals of ground-nesting species (steppe eagle, harriers) in natural steppe habitats (dry and saline steppes) (53.5%, $n=71$) than in transformed agricultural and grassland zones (5.5%, $n=256$). The frequencies of contacts with species breeding in rocks and/or trees (safe places against predators), were 46.5% in steppe habitats and 94.5% in agricultural and grassland zones and the difference was highly significant ($\chi^2=95.97$, df$=1$, $P<0.0001$). Finally, immature steppe eagles made up 33–67% of the observed individuals. They were more frequent in transformed seminatural grasslands (66.6%; $n=9$) than in natural steppes (dry and saline) (34.2%; $n=38$) although these differences did not reach significance (Fisher exact test, $P=0.129$) (Table 2).

Table 2
Proportion of raptors nesting on the ground (*Circus macrourus, Circus pygargus, Aquila nipalensis*), on rocks (*Falco cherrug, Falco naumanni*), on trees (*Falco subbuteo, Milvus migrans, Circaetus gallicus, Aquila heliaca*) or both (*Buteo rufinus, Falco tinnunculus*) in four different habitats in Eastern Kazakhstan (in brackets, number of birds observed during road counts)

	AGRI	GRASS	SALINE	STEPPE
Ground	0.6 (1)	15.9 (13)	51.4 (18)	55.5 (20)
Rock	8.0 (14)	39.0 (32)	–	5.5 (2)
Tree	9.8 (17)	2.4 (2)	11.4 (4)	8.3 (3)
Rock/tree	81.6 (142)	42.7 (35)	37.1 (13)	30.5 (11)

AGRI, highly humanized agricultural landscape; GRASS, extensive agriculture and grasslands; SALINE, saline steppe and marshlands; STEPPE, dry steppes.

Table 3
GLMs on raptor abundance in relation to habitat categories in eastern Kazakhstan

	Coeff.	S.E.	*P*
Aquila nipalensis			
Constant	−6.38439	0.96496	***
Steppe	4.19959	0.99333	***
Grass	3.03099	1.06356	**
% deviance change = 26.8%			
Buteo rufinus			
Constant	−4.52766	0.37319	***
Steppe	1.53193	0.51407	**
Saline	1.64846	0.58246	**
% deviance change = 7.6%			
Circus pygargus			
Constant	−6.49668	0.96086	***
Saline	3.95396	1.03253	***
Grass	2.63245	1.12098	*
% deviance change = 25.1%			
Circus macrourus			
Constant	−5.30823	0.49790	***
Saline	2.76551	0.62511	***
% deviance change = 19.4%			
Falco naumanni			
Constant	−3.98632	0.26644	***
Grass	2.48921	0.31975	***
% deviance change = 16.0%			
Falco tinnunculus			
Constant	−3.90801	0.44657	***
Agr	2.60343	0.45467	***
Grass	1.88961	0.50205	***
% deviance change = 10.8%			

* $P<0.05$.
** $P<0.01$.
*** $P<0.001$.

GLM models for steppe eagle and montagu's harrier explained 26.8 and 25.1% of the initial deviance respectively (Table 3). These two species were associated respectively with dry and saline steppe habitats as well as grasslands. Models for pallid harrier, lesser kestrel, common kestrel and long-legged buzzard explained 19.4, 16.0, 10.8 and 7.6% of the initial deviance, respectively. The variables entering into the models revealed that the presence of these species was increasingly independent of the degree of habitat transformation; there was a slight trend to find harriers in saline steppes, lesser kestrels in grassland and buzzards in natural steppe areas.

All the autocorrelograms, except that corresponding to steppes, showed significance for Moran's Indexes of autocorrelation after applying Bonferroni's correction, which reveals irregular spatial distribution of raptor assemblages (Fig. 2c). At low distance classes, Moran's Indexes were not significant, except for autocorrelograms b (AGRI—5 km sampling units) and c (GRASS) (Fig. 2). Autocorrelogram b showed significant positive autocorrelations at distance classes 2, 4 and 6 km, but no repeated spatial pattern was detected. Repeatable spatial patterns were only found in grassland areas where maximum numbers of raptors were regularly found at 8 km intervals.

4. Discussion

Kazakh steppe habitats seem to be very rich in raptors, which would indicate a good conservation status for these lands. The number of detected species was high (11), and the index of abundance (23–57/100 km) is similar or even higher than those found in other steppe areas of the world such as the Argentinean Patagonia (10.0–32.6 individuals/100 km, Ellis et al., 1990; Donázar et al., 1993a,b). It can be argued that the results of the surveys can be biased by several factors. For example, roads may attract scavenger species looking for cadavers, and many species perch on poles and fences so they can be more easily detected in the vicinity of roads. However, we never saw a bird of prey feeding on road-killed corpses, although some species like the black kite (*Milvus migrans*) may benefit locally. Poles and fences may, indeed, facilitate the detection of most species recorded in the area, as in other arid ecosystems (Donázar et al., 1993a,b; Leptich, 1994; Rodríguez-Estrella et al., 1998), but they would have affected all species equally (with the exception of harriers, which do not use them) thus tending to increase the numbers recorded in more developed regions.

Saline and dry steppes were the only habitats that showed no significant autocorrelograms, suggesting a uniform distribution. This may be related to the obvious homogeneous distribution of resources such as breeding places and prey. On the other hand, analyses detected a patchy spatial distribution of raptors in the other two altered habitats and a spatial pattern that repeated along grassland transects. In general, patchy distribution may be related to irregular habitat features produced by ecological heterogeneity (marsh areas in saline steppes) and clearly by human influence in grassland and agricultural areas. The apparently regular distribution of raptors in grassland areas is probably due to the spatial distribution of herder settlements, which are regularly distributed as a consequence of the collectivization of nomadic people in the mid 20th century (Fernández-Giménez, 1999a). The inhabitants now manage pastures and maintain small crops within a subsistence economy (Fernández-Giménez, 1999b). The lesser kestrel and Montagu's harrier have been able to shift breeding sites and adapt to low intensity farming systems, nesting where necessary on buildings and in cereal crops, respectively. Both species remain as breeders in pseudo-steppe habitats of Western Europe where more sensitive raptor species such as pallid harrier or steppe eagle are absent (Tucker and Heath, 1994; A. Ladyguin and V. Gory, personal communication)

Transformations in steppe habitats determine strong variations in the species composition of the different raptor communities. Five species were never detected in agricultural zones: imperial eagle, steppe eagle, saker falcon, pallid harrier and short-toed eagle, and most of them are rare outside their breeding range in Central Asia (del Hoyo et al., 1994). Rarefaction of ground-nesting species, especially eagles, may be interpreted as a result of increasing risk of predation (humans, dogs and cats) derived from human activities. Alternatively, agricultural intensification appears to reduce the abundance of medium-sized and large rodents such as susliks (*Citellus* spp. Table 1) and gerbils (*Rhombomybs* spp.), which seem to be the main prey of steppe eagle, long-legged buzzard and saker falcon (personal observation). Electrocution of raptors from power lines may also be locally important around human settlements and along roads, especially for large-sized species (Bevanger, 1998; Ferrer and Janns, 1999). Mass death of raptors on electric lines around the Zaysan Depression has been reported (Starikov, 1997) and we found two young steppe eagles electrocuted after searching under only 40 power pylons in grassland habitats .

On the other hand, transformation of natural steppe habitats has some positive effects for small and medium-sized raptors. In the vicinity of villages large predators such as wolves (*Canis lupus*) and steppe foxes (*Vulpes corsac*) may be absent (see Bird et al., 1996). Moreover, the increase in small rodents (mice and voles) is linked to agricultural sources of food.

4.1. Management implications for steppe habitats

Our results show that agricultural intensification has damaged steppe raptors in the past, but the future of raptor communities and of vertebrates in Kazakhstan seems uncertain. Progressive abandonment of intensive agriculture in central Asia may benefit large species traditionally sensitive to human presence, such as large eagles and falcons. On the other hand, smaller species such as kestrels benefit from human settlements and could be negatively affected. Probably, the long-term conservation of steppe vertebrate communities requires the maintenance of ecologically and socially sustainable grazing systems (Donázar et al., 1993a,b; Fernández-Giménez, 1999a). In parallel, it would be desirable to create and maintain large reserve zones without or with very low human presence, because numbers of certain species such as saker falcon may also be limited by falconry. Tourism activities linked to nature observation, and other low intensity uses such as regulated hunting, could help to maintain populations of large vertebrates in such areas. Further research on habitat-species relationships in Asian steppe habitats may also provide new insights for management practices in pseudo-steppe habitats in western Europe, when socioeconomic and environmental criteria of the Common Agricultural Policy (CAP) have to be updated in the next few years.

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