birds

MDPI

Article

The Structure and Spatial Distribution of the Raptor Community in the Urban Landscapes of Kyzylorda, Kazakhstan

Nurgul S. Sihanova [1], Yerlan A. Shynbergenov [1,*], Aiman B. Karabalayeva [2,3], Nurila A. Togyzbayeva [1] and Sholpan B. Abilova [2]

[1] Engineering and Technology Institute, Korkyt Ata Kyzylorda University, Ayteke bi, 29A, Kyzylorda 120014, Kazakhstan; sihanova.nurgul@mail.ru (N.S.S.); ksu@korkyt.kz (N.A.T.)
[2] Higher School of Natural Sciences, Astana International University, Kabanbay batyr avenue, 8, Astana 010017, Kazakhstan; aiman_jan@mail.ru (A.B.K.); sholpana_jan@mail.ru (S.B.A.)
[3] Faculty of Natural Sciences, L.N. Gumilyov Eurasian National University, Satpaev, 2, Astana 010008, Kazakhstan
* Correspondence: shynbergenov.erlan@mail.ru

Simple Summary

It is well known that the fitness of any species manifests as range expansion, rapid population growth, and the utilization of new ecological niches. Various species of raptors, or birds of prey, have been found living and hunting in all parts of the urban environment. Conservation in urban areas is a growing concern due to the amount of land they occupy and their pattern of development of formerly vacant land on the fringes of urban areas. Here, we can clearly see the process of synanthropization of birds, which follow the development of humanity and evolve with it. Raptors are no exception to this rule. This article focuses on the ecology of the population of raptors in Kyzylorda city (Kazakhstan) over the last seven years. We conducted call-broadcast surveys for raptors at a set of 155 survey points within the urban landscape of the Kyzylorda city area to answer the question of what landscape characteristics of cities are predictors of the presence of raptors. The detection data from these surveys was used to model the occupancy probability of the target species of raptors at each survey site and to determine the effects of landscape variables at each site on occupancy probabilities. As a result of our surveys, eight species of raptors were recorded on a permanent basis at most of the representative locations. Among all the landscape variables of Kyzylorda city, the probability of raptor presence was positively associated with the Syrdarya River floodplain and wastelands with small groups of trees and/or shrubs. It is recommended to plant more native vegetation and shrubs and to maintain areas with green spaces.

check for updates

Academic Editor: Jukka Jokimäki

Received: 11 March 2025
Revised: 1 August 2025
Accepted: 6 August 2025
Published: 17 August 2025

Citation: Sihanova, N.S.; Shynbergenov, Y.A.; Karabalayeva, A.B.; Togyzbayeva, N.A.; Abilova, S.B. The Structure and Spatial Distribution of the Raptor Community in the Urban Landscapes of Kyzylorda, Kazakhstan. *Birds* **2025**, *6*, 44. https://doi.org/10.3390/birds6030044

Copyright: © 2025 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

Abstract

In order to determine the impact of urbanization on raptors in the semi-desert conditions of southwestern Kazakhstan, an analysis of the spatio-temporal distribution of raptors is presented for the first time based on the results of surveys of the avifauna of Kyzylorda. Eight species of raptors were recorded: field Hen Harrier (*Circus cyaneus*), Marsh Harrier (*C. aeroginosus*), Eurasian Sparrowhawk (*Accipiter nisus*), Long-Legged Buzzard (*Buteo rufinus*), Eurasian Buzzard (*B. buteo*), Steppe Eagle (*Aquila nipalensis*), Eurasian Hobby (*Falco subbuteo*), and Common Kestrel (*F. tinnunculus*). The probability of raptors being present was negatively associated with dense urban low-rise buildings with limited greenery in the bay and the new part of the city. At the same time, the dense urban development with little or no greenery in the old central part of the city provides adequate habitat (including a foraging base and nesting sites) for the Common Kestrel. Raptor presence was positively

associated with the Syrdarya River floodplain and wasteland with small groups of trees and/or shrubs. The landfill site located on the north-eastern edge of the city serves as a feeding ground for the Long-Legged and Eurasian Buzzards, while the airport area is inhabited by the Eurasian Buzzard, Steppe Eagle, and Common Kestrel. Based on this study, we would recommend that enterprises (e.g., grain storage facilities, airports) and local executive bodies who are interested in the conservation of raptors and regulating the population of the pigeons around their territories should retain or plant more native vegetation and shrubs and preserve areas with green spaces.

Keywords: Kazakhstan; avifauna; landscape characteristics; Syrdarya River

1. Introduction

Rapid urbanization poses a major challenge to biodiversity conservation [1,2], as it drives landscape transformation and consequently alters species distribution and abundance [3–7]. The processes of the synanthropization and urbanization of raptors are of significant importance [8], because these birds, which are characterized by a particular sensitivity to the influence of anthropogenic pressure due to their ecological specificity, are generally recognized as biological indicators of the state of the environment [9]. It is also important to consider that the history of coexistence of humans and predators in urban environments began long before the emergence of modern cities [8]. One consequence of this process is the predation paradox, when urbanization increases the number of predators while the level of predation decreases [10].

The study of raptors in urban environments is important for several reasons. Firstly, raptors play a significant role in maintaining the ecological balance by controlling the populations of small mammals and other prey species. In urban environments, where natural habitats are fragmented, these raptors can help regulate pest populations, reducing the potential for pest-related problems [11]. Secondly, urban areas are often biodiversity hotspots, and understanding how raptors adapt to these environments can inform conservation strategies. By studying their behaviours and habitats, we can identify ways to enhance urban biodiversity [12]. As urban areas expand, conflicts may arise between humans and raptors, necessitating research into coexistence strategies. It is important to determine how raptors interact with urban environments and human populations to develop effective management strategies [13]. Predation is one of the primary forces shaping the species composition of urban animal communities, as it is in natural settings [14]. Consequently, recovering predator species colonizing urban areas should have a profound effect on their prey communities. For example, Bell et al. [15] found that the recolonization of Eurasian Sparrowhawks (*Accipiter nisus*) in Britain was correlated with a subsequent decline in House Sparrow populations. Prey abundance and urbanization influence the establishment of avian predators in a metropolitan landscape [16]. In general, urban habitats seem to provide more stable food and nesting conditions for the Northern Goshawk (*Accipiter gentilis*) than rural ones (Finland) [17].

In the modern period, ornithologists from around the world have conducted studies on the impact of urbanization on predators, which can be conditionally divided into two large groups: positive and negative impacts [18]. Regarding the first group of effects, scientists have examined the reproduction and colonization of raptors in urban landscapes in Wisconsin, USA [19]; Israel [20]; Hamburg, Germany [21]; Vienna, Austria [22]; Argentina [23]; and Jalapa, Mexico [24]. They have also studied the evolution of vision (identification and orientation in space) in urban conditions [25–28], and the trophic spe-

cialization of predators in Monegro and Seville Province, Spain [29]; Vienna, Austria [22]; and urban landfills of Kolkata, India [30]. Using the occurrence of raptors in urban areas in Argentina as an example, it was found that the index of raptor occurrence in urban areas was highest for the most common species of non-urban areas and was not related to traits such as body mass, diet, nesting sites, and migratory behaviour [23]. Extensive work has also been conducted to identify the negative impacts of urbanization on predators, such as the spread of infectious diseases and pathogens [31–33], which are exacerbated by increased interspecific competition in feeding and resting areas [34,35]. Others have studied the escape strategy of birds from predators [36] and of predators from persecution by people [33,37,38]; and collisions of predators with power lines [39]. The competitive environment of urbanized landscapes affects predators differently, and the above positive or negative effects are predators' responses to urbanization.

When assessing the degree of urbanization of raptors, Kazakh ornithologists have usually conducted research in the city limits of Almaty [40–42], Semey [43], and Pavlodar [44]. Our goal in this study was to address how Kyzylorda city can be managed and designed to incorporate raptor habitat. This goal led to two research questions: (1) What is the abundance and species composition of raptors in the landscape in Kyzylorda? (2) What landscape characteristics of Kyzylorda are predictors of the presence of raptors and individual raptor species? In general, questions regarding the consequences of predators living in an urban environment for other residents (animals, birds, and people) and the impact of urbanization on the predators themselves remain open.

2. Materials and Methods

2.1. Study Area

Currently, the Kazakh part of the Aral Sea region is undergoing significant anthropogenic transformation [45,46]. The stable financial situation and economic conditions in the country and region have contributed to the development of small- and medium-sized businesses and the opening of industrial enterprises and facilities for processing raw materials and producing goods [47,48]. The city of Kyzylorda is the administrative centre of the Kyzylorda region of the Republic of Kazakhstan. It has a total area of 240 km^2 and lies mainly in a semi-desert zone [47,49,50]. The general land use includes dense urban development in the central part of Kyzylorda city; less dense residential, commercial, and business development on the left bank of the Syr Darya River; suburban areas from the northeast to the southeast; and agricultural land and greenhouses, mainly in the southern and western parts of the study area [51,52]. Forested green areas (parks, squares, gardens, and boulevards) are found in the central and southern parts of the city, while groves of turanga (*Populus euphratica*) and oleaster (*Elaeagnus angustifolia* L.)—locally called "tugai"—are located in the Syr Darya River valley [53,54]. Kyzylorda is the administrative centre of the Aral Sea region, with a population of 353,248 people [55], and is considered a large city, with dynamic growth in area and building density. Accordingly, the area of undeveloped urban territories is decreasing, and the intensity of recreational load on them is increasing significantly [56]. Undeveloped land is either landscaped for aesthetic purposes or left for existing vegetation and may include vacant lots that are either designated as common land or available for potential future development. The study area, as shown in [57], is located within the Asian Arid Zone (35–55° N; 60–120° E).

2.2. Delineating the Study Site

To create the study area for the urban raptor population sample, we created a map layer in QGIS [58], consisting of land parcels in Kyzylorda. The cartographic base for creating the layer was downloaded from the OpenStreetMap (OSM) web mapping project,

and the data files were exported from the Geofabric Downloads server, where an archive catalogue is presented based on continent name. We selected the Asia subregion, found Kazakhstan, and downloaded the data in a shapefile format (shp). After unzipping the archive, we selected our study area (Kyzylorda city within the administrative boundaries) and deleted the remainder from the layer attribute table. To create a set of survey points, we created a grid of points that covered the area of Kyzylorda city. We placed the points 500 m apart to obtain a favourable number of survey points in the city and ensure independence between potential observations at each point. We clipped this grid to the boundaries of the Kyzylorda layer and carefully examined the resulting point layer to identify suitable survey locations. We moved survey location points up to 100 m from their original grid locations to place them in suitable locations away from buildings to ensure favourable sightlines, provided that this did not place the point within 500 m of any neighbouring points. Points that could not be moved sufficiently to meet these guidelines were removed. We then obtained permission from each company that was covered by a survey point to access their land for the purpose of conducting raptor surveys. Points for which permission could not be obtained were removed. We placed a total of 155 survey points to collect raptor presence data (Figure 1).

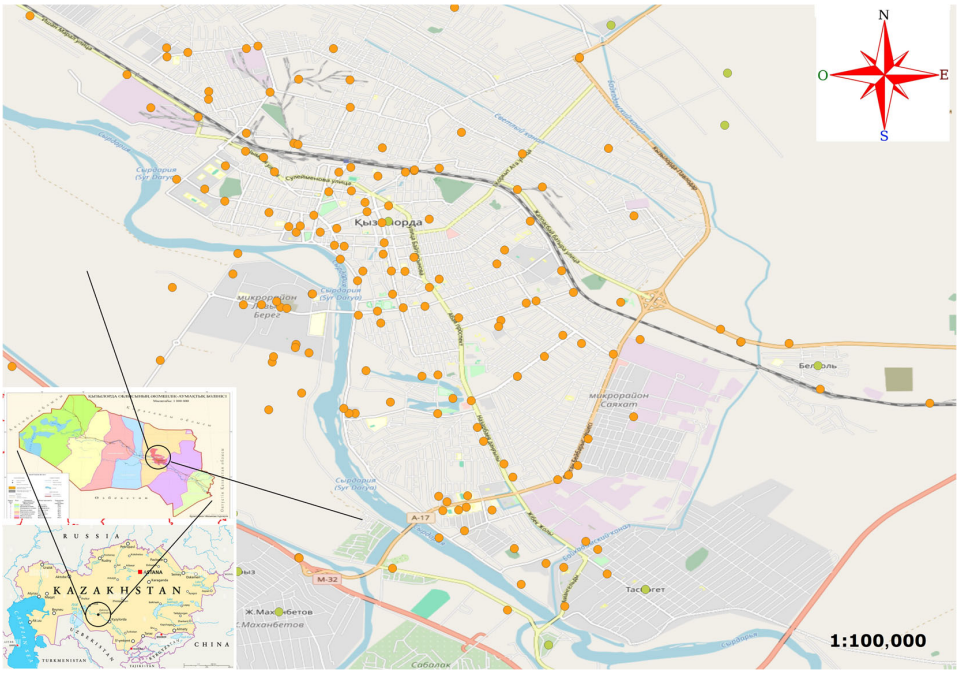


Figure 1. Map of survey points: the city of Kyzylorda and the Republic of Kazakhstan.

We made a concerted effort to cover as much of the Kyzylorda city landscape as possible and to place points in a largely randomized manner. Due to access issues, some degree of variation in point selection was unavoidable, but we were still able to place points in all major areas of anthropogenic intervention within the study area, and we do not believe that the lack of access to certain locations resulted in undue bias in the placement of survey points.

2.3. Raptor Surveys

We conducted a pilot survey in July 2018 at 70 locations to assess the project logistics and detected 8 species of raptors. The next count was organized in October 2018, during the autumn migration period, to establish the possibility of vacant niche dominants being replaced by incoming migratory raptors.

The main raptor surveys were conducted in the morning hours after sunrise during the spring–summer (15.03–30.06) survey season from 2018 through 2024, during the migration and breeding periods. The surveyor's equipment included eight- (8 × 30) and twelve-power (12 × 45) binoculars, a telescope (55–65×; lens diameter 65 mm, Celestron), and professional photographic equipment (Canon EOS 600D + Canon EF 70–200 mm F/2.8 L USM).

We recorded all detected raptor species seen or heard within a radius of 500 m from the observation point for a fixed 10 min. Bird surveys were conducted simultaneously in several areas by separate groups of surveyors (2 surveyors in each group). Bird surveys started immediately after sunrise, the maximum number of points was surveyed in 2–3 h, and each subsequent day new points were surveyed in a different area of the city. In general, bird surveys in the period 2018–2024 were conducted between mid-March and late June. We surveyed 150 survey points once per month for a total of four times each, and we surveyed five points only two or three times due to access issues. To reduce double-counting within a single observation period, we excluded subsequent counts of individuals suspected to have been previously recorded (e.g., same species in the same general area), but included any changes in flight height, behaviour, and response with the first observation for that individual.

Quantitative surveys in parks, turanga groves, and the Syr Darya River floodplain within the city boundaries were conducted by laying points on transects at intervals of three kilometres so that there was minimal overlap of the viewing segments. In areas of the city with dense high-rise buildings, observations were carried out from high-rise buildings that had a dominant position in the terrain. These routes were passed repeatedly throughout all seasons of the year. All bird registrations (taking into account the flight direction and attachment to a specific site) were geolocated in the Maps Me mobile application [59], and the locations of the points were uploaded to QGIS software (V3.44 for Windows).

The approximate affiliation of raptors to topical nesting pairs or vagrants to a given station was recorded by assessing the directions of movement routes based on the presence or absence of a targeted flight to the usual nests (no special studies of nests were conducted; this statement is based on visual contact by the surveyors.) or perches of nesting birds, including the nature of the overnight roosting sites of birds (for local birds, individual regular overnight sites were known). When the owners of the territory appeared, the intruders hastily left the hunting territory; otherwise, attempts to displace and expel rivals from the hunting site were observed.

2.4. Collection of Environmental Variables

We collected the following study-specific environmental variables that are believed to be associated with the probability of detecting raptors in each study location: the date of the study (expressed as a Gregorian date); the time of day that the study was conducted (expressed in minutes since sunrise); the temperature (estimated using local weather forecasts, available via mobile phone); the percentage of cloud cover; the wind speed (Beaufort scale); and the visibility level [60–62]. We recorded the visibility level from each viewpoint based on how much of the view of the surrounding landscape was blocked by nearby vegetation and/or buildings. This variable was created by taking photographs at each viewpoint facing each of the four cardinal directions and viewing these photographs on a computer screen. We created a paper mask with five one-inch-diameter holes, evenly spaced along a line just above the horizon, and placed it on the computer screen to view each photograph. We counted the number of holes where the distance to the nearest viewing obstruction was greater than 100 m and averaged this across four photographs to obtain a visibility score from 0 (poor visibility of surrounding landscape, many nearby obstructions) to 5 (high visibility of surrounding landscape) [63]. We designed the raptor

surveys to minimize the potential influence of study-specific variables, such as the time and weather. We conducted repeated surveys at given locations at different times of the morning to reduce potential bias due to the time of day, as well as noise levels, which were generally lower in the early morning due to lower levels of human activity.

2.5. Landscape Measurements

We measured landscape variables that may correlate with the presence of raptors within 500 m buffers (survey plots) drawn around each survey point. Site sizes were set with a radius of 500 m to minimize any overlap between sites. We used high- and ultra-high-resolution satellite remote sensing images from the archived catalogue of the Google Earth navigation software (V7.1.8.3036 (Windows)) [64], made freely available, to delineate discrete areas of different land cover types (Figure 2): open green spaces (wastelands and the Syrdarya River floodplain with groups of trees and/or shrubs); afforested green areas (parks, squares, gardens, and boulevards); asphalted and concretized spaces (wide streets and squares); areas without buildings (a range of multi-storey building plots, wooded areas, and open green spaces); commercial and industrial facilities (shopping centres, grain stores, rice mills, warehouses, railway sidings, etc.); dense urban development with limited landscaping (isolated groups of trees and shrubs are present); and dense urban development with little or no greenery (old city centre districts). Hereafter, the term "dense urban development" (also called "high-density development") refers to a type of development in which buildings are located close together, resulting in a high density of buildings per unit area.

In describing the distribution of raptors in Kyzylorda, we used the classification of urban landscapes proposed by B. Klausnitzer [65] and adapted it to our conditions.

At each site, we measured the following: the proportion of the plot with different cover type; the mean plot size of green areas, grass, trees, and shrubs; and the edge ratio of grass and forest cover types (the total length of the edges of all plots of a particular cover type, divided by the total area of all plots of that cover type). The descriptive statistics of all landscape variables are summarized in Table 1.

Table 1. Descriptive statistics of measured landscape variables of all 155 points in the study area.

Parameter	Variable	Mean	Mean Square Deviation
Proportion of the study area	Dense urban development with little or no landscaping	0.109	0.006
	Commercial and industrial buildings	0.018	0.034
	Open green spaces	0.079	0.004
	Paved and concreted areas	0.225	0.009
	Vacant built-up areas	0.223	0.017
	Forested green spaces	0.040	0.002
	Dense urban development with limited green space	0.195	0.014
Mean plot area (ha)	Open green spaces	1.399	0.096
	Forested green spaces	0.500	0.026
Edge ratio (perimeter/area)	Open green spaces	0.063	0.003
	Forested green spaces	0.055	0.005
	Visibility	1.358	0.083



Figure 2. Sample survey area with designated cover types. The cover types are as follows: (**A**) vacant buildings (the "Left Bank" microdistrict, tugai on the outskirts of the left bank of the Syrdarya river); (**B**) afforested green areas (Park of the First President); (**C**) commercial facilities (shopping and entertainment centres) and dense urban development with limited greenery (ancient bed of the Syrdarya River); (**D**) industrial areas (grain storage, warehouses, railway dead ends); (**E**) open green spaces (landfill, stationary asphalt concrete plant, city cemetery).

The descriptive statistics of the survey site were calculated using the QGIS software (V3.44 for Windows) package.

2.6. Statistical Methods

We used detection data for each site during the survey season to construct models of detection and occupancy probabilities using a two-stage information-theoretic modelling approach [66,67]. The first stage modelled the probability of detection for each survey, and the second stage modelled the probability of occupancy at each survey point, including the detection variables that were identified in the best-fitting model from the first stage.

In both stages, we tested the same set of candidate models with four different datasets: detection of any of the five target species, detection of Common Kestrel, detection of Steppe Eagle, and detection of Hen Harrier. We chose to model an all-species dataset in order to see if there were any effects of landscape variables on the guild of diurnal raptors, which constitutes an apex predator guild. We analysed the candidate models using PRESENCE

5.3 software [68] and ranked them using the Akaike information criterion, adjusted for a small sample size (AICc).

In the first stage, we modelled the detection probability (p) with detection variables measured during each survey: the time of day, time of year, temperature (estimated), cloud cover, wind speed, noise level, and visibility level. We added an interaction variable date*temperature to the analyses to test the hypothesis that the effect of temperature on the detection probability changed as the weather became warmer from spring to summer. These variables were entered into a direct stepwise procedure to identify a set of candidate models [69]. We used this approach to give each variable equal attention and retain or exclude them from the candidate model set based on how well they fit the data.

In the second stage, we created a set of candidate models to test the effects of measured landscape variables on the observed variation in occupancy (ψ) between survey sites, given the modelled detection probabilities [67,70,71]. We grouped variables into candidate models to test hypotheses about whether the presence of raptors was associated with broader patterns of land cover. We hypothesized that the presence of more developed and cleared space (streets and pavements) would negatively affect raptor presence [72,73], that the presence of more open space (wastelands and floodplains) would positively affect the presence of some raptors and negatively affect others [74–76], and that the presence of more natural land cover (grass and heathland) in general [72,73] and woody cover (trees and shrubs) in particular [70,75,77] would have a positive effect on the presence of raptors. We also created models with the mean size of each patch of three natural cover types (vacant lots, shrubs, and trees) and the overall edge ratio (perimeter/area) of these cover types to test whether large areas or multiple interior habitats of these cover types had a positive effect on raptor presence and whether this should be planned for in urban development [72,76,78,79]. The candidate set also included models testing the effects of the proportions of building, commercial, and residential cover; a null model with all landscape variables held constant; and a fully parameterized global model with all landscape variables (Table 2).

We assessed the quality of the fit for candidate models by calculating Pearson's chi-square statistic (χ^2) for the global model [80,81]. We also calculated the excess variance parameter (ĉ) from 1000 parametric bootstraps of employment data in the PRESENCE programme. A value of ĉ close to 1 was considered an indication of a good model fit to the data. A value of ĉ greater than 1 indicated that the data were overdispersed or that there was greater variation in the observed data than expected from the global model given the observed habitat data. In cases where ĉ was greater than 1, the value of ĉ was used to adjust the AICc estimates to quasi-Akaike or QAICc estimates. Akaike weights were adjusted accordingly, and the standard errors of the model coefficients were increased by the square root of ĉ to account for the large observed variance [66].

To account for model uncertainty, we calculated the mean linear regression coefficient estimates for variables in the model set that contained 90% of the total Akaike weight of the candidate set to determine which parameters contributed the most to the variation in detection and occupancy [66,67]. Odds ratios were calculated from these coefficient estimates, and confidence intervals were calculated around these odds ratios to determine which variables in the 90% model set had a significant effect on the probability of employment. Odds ratios were considered significant if their 90% confidence interval did not include 1, as an odds ratio of 1 would indicate that the variable had no effect on the probability of employment.

Table 2. Set of a priori candidate occupancy models created to test the relationship of measured landscape variables with the probability of raptor occupancy at each survey site.

Model	Description
Ψ (dud)	Coverage of dense urban development with little or no landscaping
Ψ (comm)	Coverage of commercial premises
Ψ (vl)	Coverage of vacant land
Ψ (OS)	Open space model (% of area covered by wasteland and floodplain)
Ψ (NS)	Natural space model (% of area covered by grass and wasteland)
Ψ (CS)	Cleared space model (% of area covered by paved and concreted areas)
Ψ (TM)	Tree model (% of area covered by open green space and afforested green space)
Ψ (NP)	Mean area of natural plots (grass and wasteland)
Ψ (PT)	Mean area of plots with trees (open green space and afforested green space)
Ψ (AV)	All variables of mean area (open green space and afforested green space)
Ψ (NPRE)	Ratio of edges of natural plots (perimeter/area)
Ψ (.)	Null model
Ψ (GL.)	All variables

3. Results

3.1. Registration of Raptors

We recorded raptors at 99 of the 155 survey points and recorded 224 detections of raptors during the field season (Table 3).

Table 3. Raptors species recording results during 2018–2024.

Species [80,81]	Scientific Name [80,81]	Total Number of Observations	Number of Observation Points (Where Species Is Detected)	Number of Points Detected Divided by Total Number of Survey Points
All target species		210	93	0.6
Common Kestrel	*Falco tinnunculus*	105	61	0.39
Steppe Eagle	*Aqulia nipalensis*	75	37	0.24
Hen Harrier	*Circus cyaneus*	25	20	0.13
Eurasian Sparrowhawk	*Accipiter nisus*	4	3	0.013
Long-Legged Buzzard	*Buteo rufinus*	3	2	0.013
Other types				
Marsh Harrier	*Circus aeroginosus*	2	2	0.013
Eurasian Buzzard	*Buteo buteo*	2	2	0.013
Eurasian Hobby	*Falco subbuteo*	1	1	0.007
Unidentified		7	7	null

The Eurasian Sparrowhawk (*Accipiter nisus*) and Long-Legged Buzzard (*Buteo rufinus*) were only detected at three and two locations, respectively, and were excluded from consideration in the individual species modelling. Their detections were included in the target species for which calls were broadcast. Other raptor species that were detected at least once were the Marsh Harrier (*Circus aeroginosus*), Eurasian Buzzard (*Buteo buteo*), and Eurasian Hobby (*Falco subbuteo*).

3.2. Recording Models

The most supported detection model for all the target species included the date, temperature, and visibility ($\hat{c}$ = 1.1979; p = 0.2607). The detection probability was positively related to the temperature and visibility and negatively related to the date, meaning that the detection probability was higher early in the season. The best-supported model for analysing Common Kestrels (*Falco tinnunculus*) included an interaction between date and temperature and visibility ($\hat{c}$ = 0.9888; p = 0.2777). The detection probability was positively related to the visibility and negatively related to the date and temperature for Common Kestrel. The best-supported model for the Steppe Eagle was the temperature model, in which the detection probability was positively related to the temperature ($\hat{c}$ = 0.9932; p = 0.3357). Hen Harrier (*Circus cyaneus*) detection probability was negatively related to noise and visibility, and the global model showed a good fit to the data ($\hat{c}$ = 0.6181; p = 0.2957) (Table 4).

Table 4. Best detection models (90% of the total Akaike weight) based on the detection data analysis, ranked by Akaike information criterion (AIC) or quasi-AIC and corrected by $\hat{c}$ value if necessary. ΔAIC is the difference in AIC value from the best model.

Species	Model	QAIC	ΔAIC	AIC wt.	No. Par.	−2 × Log-Like
All five target species	Ψ (.), *p* (d + t + r)	570.01	0	0.241	5	670.84
	Ψ (.), *p* (d + t)	571.04	1.03	0.144	4	674.46
	Ψ (.), *p* (t + r)	571.14	1.13	0.137	4	674.59
	Ψ (.), *p* (t)	571.69	1.68	0.104	3	677.64
	Ψ (.), *p* (ti)	572.43	2.42	0.072	3	678.53
	Ψ (.), *p* (ti + r)	572.5	2.49	0.070	4	676.21
	Ψ (.), *p* (.)	572.7	2.69	0.063	2	681.24
	Ψ (.), *p* (r)	572.8	2.79	0.060	3	678.97
	Ψ (.), *p* (c)	574.29	4.28	0.028	3	680.76
Common Kestrel	Ψ (.), *p* (d + t + dt + r)	479.45	0	0.431	6	467.45
	Ψ (.), *p* (d + t + dt + r + ti)	479.69	0.24	0.382	7	465.69
	Ψ (.), *p* (d + t + dt + ti)	484.14	4.69	0.041	6	472.14
	Ψ (.), *p* (d + t + dt)	484.65	5.2	0.032	5	474.65
	Ψ (.), *p* (ti + r)	485.09	5.64	0.026	4	477.09
Steppe Eagle	Ψ (.), *p* (t)	346.98	0	0.427	3	340.98
	Ψ (.), *p* (c + ti)	347.18	0.2	0.386	4	339.18
	Ψ (.), *p* (c)	350.37	3.39	0.078	3	344.37
	Ψ (.), *p* (d)	351.6	4.62	0.042	3	345.6
Hen Harrier	Ψ (.), *p* (n + r)	182.26	0	0.421	4	174.26
	Ψ (.), *p* (n)	183.59	1.33	0.216	3	177.59
	Ψ (.), *p* (d + r)	185.31	3.05	0.092	4	177.31
	Ψ (.), *p* (r)	185.52	3.26	0.082	3	179.52
	Ψ (.), *p* (d)	186.67	4.41	0.046	3	180.67
	Ψ (.), *p* (.)	186.9	4.64	0.041	2	182.9

Note: Hereafter, d—date; t—temperature; ti—time; r—review; c—cloud.

3.3. Landscape Models

The best model for predicting occupancy of the residential landscape for all target species of raptors was the open space model (wastelands and the Syrdarya River floodplain with small groups of trees and/or shrubs) (Table 5).

Table 5. Occupancy models (90% of the total Akaike weight) based on detection data analysis, ranked by Akaike information criterion (AIC) or quasi-AIC and adjusted by ĉ value if necessary. ΔAIC is the difference in AIC value with the top model. Each model includes detection variables from the upper detection model (see Table 4).

	Model	QAIC	ΔAIC	AIC wt.	No. Par.	−2 × Log-Like
All five target species	Ψ (OS), *p* (d + t + r)	570.64	0	0.239	7	660.34
	Ψ (FD), *p* (d + t + r)	572.23	2.65	0.108	6	664.4
	Ψ (CS), *p* (d + t + r)	572.28	2.7	0.105	4	669.4
	Ψ (CS), *p* (.)	572.28	2.7	0.105	4	669.4
	Ψ (Gl.), *p* (d + t + r)	573.5	3.92	0.057	19	635.26
Common Kestrel	Ψ (TM), *p* (d + t + dt + r)	380.02	0	0.228	8	459.03
	Ψ (NS), *p* (d + t + dt + r)	381.36	1.34	0.117	8	460.72
	Ψ (NP), *p* (d + t + dt + r)	381.59	1.57	0.104	8	461.01
	Ψ (PT), *p* (d + t + dt + r)	381.59	1.57	0.104	8	431.01
	Ψ (OS), *p* (d + t + dt + r)	381.77	1.75	0.095	8	461.23
	Ψ (CS), *p* (d + t + dt + r)	382.1	2.08	0.081	8	461.65
	Ψ (CIC), *p* (d + t + dt + r)	382.52	2.5	0.065	7	464.71
	Ψ (NM), *p* (d + t + dt + r)	382.69	2.67	0.060	6	467.44
	Ψ (FD), *p* (d + t + dt + r)	382.23	3.21	0.046	7	465.6
Steppe Eagle	Ψ (NS), *p* (t)	200.98	0	0.412	5	325.47
	Ψ (OS), *p* (t)	202.62	1.64	0.181	5	328.26
	Ψ (NP), *p* (t)	203.41	2.43	0.122	5	329.61
	Ψ (NS), *p* (.)	204.48	3.5	0.072	4	334.84
	Ψ (NS), *p* (t)	204.78	3.8	0.062	6	328.53
	Ψ (TM), *p* (t)	205.2	4.22	0.050	5	332.66
Hen Harrier	Ψ (FD), *p* (n + r)	179.98	0	0.436	5	169.98
	Ψ (FD), *p* (.)	181.68	1.7	0.186	3	175.68
	Ψ (CIC), *p* (n + r)	182.46	2.48	0.126	5	172.46
	Ψ (Gl.), *p* (n + r)	183.11	3.13	0.091	18	147.11
	Ψ (OS), *p* (n + r)	183.14	3.16	0.090	6	171.14

Notes: OS—open space model; FD—free development model; CS—cleared space model; Gl.—global; TM—tree model; NS—natural space model; NP—mean area of natural plots; CIC—commercial and industrial coverage; PT—mean area of plots with trees; NM—null model.

Occupancy by individuals of the five target species was most strongly and negatively related to the amount of open green space that was present in the surveyed area (ĉ = 1.1863; p = 0.1548). The Syrdarya River floodplain and wastelands were present in the top two models, accounting for 64% of the total Akaike weight of the candidate set. Three other variables, wide streets and squares, grass, and vacant development, appeared in the top 90% of the model set. The occupancy probabilities of the five target species were negatively related to the amount of open green space and wide streets and positively

related to the amount of grass and vacant development (alternating patches of mixed-use development, woodland, and open green space). Only open green areas had a significant odds ratio at 90% confidence (Table 6).

Table 6. Model's mean coefficients, odds ratios, and 90% confidence intervals of the odds ratios for landscape variables in the detection data analysis. Variables marked with an asterisk (*) have 90% odds ratio confidence intervals that do not include 1 and, therefore, have a significant effect on the detection probability.

	Variable	Coefficient	SE	Odds Ratio	90% CI
All five target species	Intercept	1.372	0.644		
	Floodplain *	−0.634	0.374	0.531	0.287–0.981
	Pavement	–0.028	0.700	0.972	0.308–3.072
	Grass	1.104	1.809	3.015	0.154–59.15
	Free Development	2.712	2.786	15.06	0.154–1472
Common Kestrel	Intercept	0.950	0.721		
	Tree *	1.231	0.704	3.425	1.075–10.91
	Tree	0.374	0.340	1.453	0.831–2.544
	Grass_mean	0.022	0.373	1.022	0.553–1.188
	Wood_mean	2.468	1.567	11.80	0.899–155.2
	Tree_mean	0.002	0.298	1.002	0.614–1.636
	Grass	–0.047	0.313	0.954	0.571–1.596
	Floodplain *	–0.675	0.305	0.509	0.308–0.842
	Pavement	–0.002	0.282	0.998	0.628–1.587
	Residential	0.465	0.407	1.592	0.815–3.110
	Commercial *	–0.434	0.263	0.648	0.420–0.999
Steppe Eagle	Intercept	–0.838	0.357		
	Grass *	0.772	0.351	2.164	1.215–3.853
	Floodplain	–0.087	0.337	0.917	0.527–1.595
	Tree	–0.434	0.348	0.648	0.366–1.148
	Grass_mean	0.841	0.413	2.319	1.176–4.573
	Shrub_mean	–0.194	0.336	0.824	0.474–1.433
	Tree_mean	–0.238	0.306	0.788	0.477–1.303
	Tree	–0.501	0.406	0.606	0.311–1.182
	Intercept	1.263	3.986		
Hen Harrier	Residential *	1.095	0.658	2.988	1.013–8.816
	Commercial	15.01	39.39	3.6×10^{6}	2.6×10^{-22}–5.0×10^{34}
	Grass *	–1.211	0.750	0.290	0.088–0.955
	Floodplain	–0.498	0.478	0.608	0.277–1.335

According to the models, the probability of raptor occupancy increased by about 12% with every 5% addition of open green space area (Figure 3A).

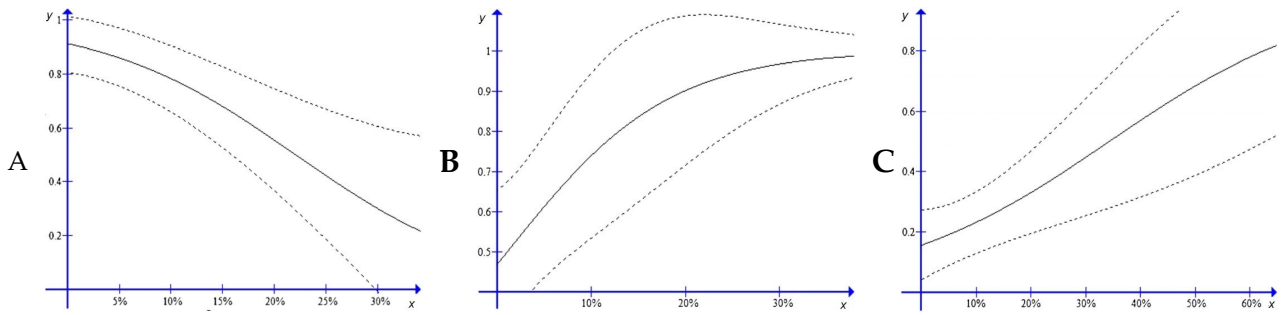


Figure 3. Effects of the proportion of the surveyed area on the predicted probability of occupancy with a 90% confidence interval, calculated using the model-averaged coefficient from the best models, where the vertical axis (y) is the predictor Ψ, and the horizontal axis (x) is open green space, where (**A**) is any of the five target raptor species, (**B**) is the Common Kestrel, and (**C**) is the Steppe Eagle.

The model of forested green areas (parks, squares, gardens, and boulevards) was the best-performing model in the analysis of the Common Kestrel. The amount of green space was the most important predictor of occupancy probability, appearing in the top two models (ĉ = 1.2610; p = 0.1568) (Table 5). The amount of woodland and commercial land and the variables of wasteland and floodplain were all significant at the 90% level (Table 6). Occupancy probability was positively associated with trees and the average size of green space patches and negatively associated with floodplains and the commercial sector. The probability of Common Kestrel occupancy increased by about 20% with each 10% increase in green space cover (Figure 3B). The natural cover model was the leading model in the analysis of the Steppe Eagle (*Aqulia nipalensis*), although two variables in the model (grass and vacant lots) had opposite effects. Open green space was identified as the most important predictor of occupancy in the Steppe Eagle analysis, appearing in the top two models (ĉ = 1.7042; p = 0.0849) (Table 5). The associations of open green space and average patch area with eagle occupancy were positive, and the model-averaged odds ratio for open green space was significant at the 90% level (Table 6). The probability of Steppe Eagle occupancy increased by approximately 12% with each 10% increase in grass cover, wastelands, and floodplain with groups of trees and/or shrubs (Figure 3C). The occupancy probability was also positively associated with the average herbaceous vegetation height and negatively associated with dense urban development with limited greenery. The best models for the Hen Harrier analysis did not converge in terms of maximum likelihood, which was most likely due to the small sample size of Hen Harrier detections (Table 5). We discarded the models that did not converge and recalculated the 90% Akaike weight set and model means for the remaining landscape variables (Table 6). The best-performing model in this set was the open space model (ĉ = 0.5452; p = 0.5784).

4. Discussion

The most frequently encountered birds were the Common Kestrel and Steppe Eagle, while the Hen Harrier was also present in significant numbers. Somewhat less expected species, the Eurasian Sparrowhawk and Long-Legged Buzzard, were also present in the study area. While the Marsh Harrier [77] and Eurasian Buzzard [78] are known to successfully adapt to urban environments, we did not detect many representatives of either species. Avifauna surveys are traditionally carried out immediately after sunrise to observe specific bird communities when they are most active [79], but in this study, the detection rates were only weakly correlated with the time of day and generally positively, suggesting that raptors are easier to detect later in the morning. For the smallest raptor in this study, the Common Kestrel, temperature was the most important variable, showing a positive correlation with the detection probability. The date*temperature interaction variable showed a

negative correlation with detection probability for the Common Kestrel, suggesting that the detection probability was positively correlated with the temperature early in the season and negatively correlated late in the season. This is consistent with avoidance of both excessive cold and excessive heat. The visibility index was positively correlated with detection probability of the Common Kestrel, but negatively correlated with detection probability of the Hen Harrier, possibly owing to the large amounts of tree cover in survey sites with Hen Harrier detections. The noise level only seemed to affect the probability of detecting Hen Harrier.

Although a joint analysis of all target species may cancel out habitat preferences that vary between species, general habitat associations within bird communities may still emerge. The top model in the target species analysis was the open space model, which shows that, as the proportion of heavily modified land (paved and concreted areas) increases, the probability of raptor presence decreases, as predicted. Sidewalks and wide streets were also found to be negative indicators in all single-species analyses. The negative effect of paved and concrete spaces was even greater than that observed for the number of wide streets and squares across the study sites, despite the large variance in the number of wide streets across the study area (the proportion of sidewalks ranges from 0.4 to 30.8%, while the proportion of wide streets ranges from 1.6 to 52.3%).

Although the Common Kestrel is one of the most studied raptors in the world, studies have mainly examined the breeding performance of Common Kestrels living in rural areas in Europe [22,82–84], and only a few studies have looked at the breeding success of kestrels in urban habitats [85–87]. Most studies have found that kestrels breeding in urban areas have higher breeding rates than those in rural areas, with the exception of Kübler et al. [87], who found no difference. The general green space model (riparian forests, parks, gardens) has been the main model used in analyses of the Common Kestrel, and the second most supported model, natural cover, also includes green space. The Common Kestrel is the most ecologically flexible species of all small falcons and can choose transformed habitats as a nesting site, willingly settling, mainly in the nests of corvids, as well as in field-protective roadside forest belts, attics, and the cornices of anthropogenic structures [18,82,84,88–91]. The available literature contains information on the nesting habits of Common Kestrel in the Kazakh cities of Semey [92,93] and Kurchatov [94] and the Kazakh part of the Altai Mountains [90]. In this study, Common Kestrels were found throughout the city of Kyzylorda, but there were noticeably fewer in parts of the study area that were predominantly unvegetated. We assume that this is due to the lower breeding success of the kestrel in open natural nesting sites than in the cavity nesting sites reported by Kostrzewa and Kostrzewa [83].

The Steppe Eagle is the most common raptor in the more open parts of the study area, and the performance of the natural cover model reflects this. Grassland was a positive predictor of Steppe Eagle presence [95], while green space was a negative predictor. This is consistent with other studies of Steppe Eagles' habitat preference for nesting and hunting in Chimkent [96], Almaty [38], and Aktau [97]. There is evidence that the Steppe Eagle population in Kazakhstan has been gradually decreasing in recent years [88,98,99], so conservation of steppe and semi-desert landscapes may be important for this species [95]. In addition, species protection during migration and in wintering grounds can often increase Steppe Eagle numbers in the country and region [98,100]. The best models in the Hen Harrier analysis did not converge; therefore, we did not draw conclusions about habitat relationships from them. In the remaining main models, Hen Harriers showed positive associations with residential areas and forested green areas and negative associations with commercial development, river floodplains, and vacant lots with small groups of trees and/or shrubs [101]. Most residential areas in Kyzylorda have limited greenery cover and

may also support healthy populations of small birds that Hen Harriers prey on in urban landscapes [88,102–105]. Hen Harriers were also generally absent from dense urban areas with little or no greenery and industrial areas. Having a larger sample size of detections to study would likely lead to more detailed habitat conclusions. The size and shape of habitat patches did not seem to matter as much as the total number of such patches in the study area. Raptors tend to migrate long distances and live at low population densities in the landscape [106,107]. The Common Kestrel's home range averages 14–20 ha in southern Kazakhstan [92,108], which is significantly different from the hunting grounds in the urban environment of Zagreb, Croatia (0.8–25 km^2) [109], and Algeria (5.92–255.07 ha) [110], as well as those found in the vicinity of Parma, northern Italy (28–142 ha or an average of 74 $\pm$ 8.0 ha) [111]. Meanwhile, the Hen Harrier's home range averages 65 ha in Aktau [103], which is an order of magnitude smaller than the average home range size of 7 km^2 recorded in the Slieve Bloom Mountains, Ireland [112], while the area of its hunting grounds in Scotland ranges from 0.25 to 46 km^2 [113]. One can endlessly compare various quantitative aspects of the Kyzylorda raptor habitat with similar ones in other countries, which are impacted by the level of urbanization (the size of residential areas and height of buildings) and anthropogenic intervention, mosaic relief and land use patterns, and the availability of foraging areas and shelter. Therefore, raptors can select habitats on a scale larger than the individual habitat patches that are usually found in the urban landscape and larger than the survey sites selected for this study [107].

We also studied what developers and owners of industrial facilities can do to improve the quality of habitats for raptors. A survey of several employees or owners of grain storage facilities, warehouses, and railway sidings revealed their satisfaction with the prospect of raptors appearing on their premises. They also shared their observations regarding the territory. A raptor species that can adapt to the cultural landscape will depend on the landscape in and around the city, as well as the wider ecological context in which Kyzylorda is located. Therefore, the findings of this study mainly focus on urban areas of southwestern Kazakhstan. In areas that are mainly open floodplains, pastures, or agriculture, the Steppe Eagle will be the most likely species to be encountered. With tree numbers increasing in residential areas and riparian forests or residential areas with mature greenery regrowing, Common Kestrels are the most likely to occupy such areas, followed by Hen Harriers. However, regardless of their surroundings, maintaining areas of floodplains and native greenery and limiting the amount of intensively developed land may increase the likelihood of observing these raptors hunting and/or nesting in the city. We consider the main limitation of this study to be the lack of a detailed study of the feeding specialization of the Eurasian Buzzard and Long-Legged Buzzard, which were observed in the vicinity of the municipal solid waste landfill (opened in 2022), and its impact on the level of predation [10].

Author Contributions: Conceptualization, N.S.S., A.B.K. and Y.A.S.; methodology, N.S.S., A.B.K., S.B.A. and Y.A.S.; data collection, N.S.S., A.B.K. and N.A.T.; formal analysis, N.S.S. and A.B.K.; writing—original draft preparation, A.B.K., S.B.A. and N.A.T.; writing—review and editing, N.S.S., A.B.K. and S.B.A.; visualization, Y.A.S.; project administration, N.S.S. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Committee of Science of the Ministry of Science and Higher Education of the Republic of Kazakhstan (Grant No. AP22685801): "Ecology of birds of prey in conditions of urbanization (on the example of the city of Kyzylorda)".

Institutional Review Board Statement: Ethical review and approval were waived for this study, as it involved only the observation of birds without any capture or manipulation.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Acknowledgments: We are grateful to the anonymous reviewers for their time and constructive feedback to improve the scientific value of our work. We express our gratitude to the Academic Editor of the journal for detailed reading of the work at the preliminary stage, detailed elaboration of the main issues, and support provided during the process of preparing this article for publication.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Dearborn, D.C.; Kark, S. Motivations for conserving urban biodiversity. *Conserv. Biol.* **2010**, *24*, 432–440. [CrossRef]
2. Frantz, A.; Baneux, M.; Pichon, L.; Renier, S.; Vilanova, J. Flight initiation distance differs among eumelanin-based color morphs in feral pigeons. *J. Zool.* **2025**, *325*, 115–123. [CrossRef]
3. Papouchis, C.M.; Singer, F.J.; Sloan, W.B. Responses of desert bighorn sheep to increased human recreation. *J. Wildl. Manag.* **2001**, *65*, 573–582. Available online: https://www.jstor.org/stable/3803110 (accessed on 1 March 2025). [CrossRef]
4. Parris, K.M.; Schneider, A. Impacts of traffic noise and traffic volume on birds of roadside habitats. *Ecol. Soc.* **2009**, *14*, 29. Available online: https://www.ecologyandsociety.org/vol14/iss1/art29/ (accessed on 1 March 2025). [CrossRef]
5. Rebolo-Ifrán, N.; Carrete, M.; Sanz-Aguilar, A.; Tella, J.L. Links between fear of humans, stress and survival support a non-random distribution of birds among urban and rural habitats. *Sci. Rep.* **2015**, *5*, 13723. [CrossRef] [PubMed]
6. Schlesinger, M.D.; Manley, P.N.; Holyoak, M. Distinguishing stressors acting on land bird communities in an urbanizing environment. *Ecology* **2008**, *89*, 2302–2314. [CrossRef]
7. Smith, J.A.; McDaniels, M.E.; Peacor, S.D.; Bolas, E.C.; Cherry, M.J.; Dorn, N.J.; Feldman, O.K.; Kimbro, D.L.; Leonhardt, E.K.; Peckham, N.E.; et al. Population and community consequences of perceived risk from humans in wildlife. *Ecol. Lett.* **2024**, *27*, e14456. [CrossRef]
8. Bildstein, K.L.; Therrien, J.F. Urban Raptors: A Lengthy History of Human-Raptor Cohabitation. In *Urban Raptors*; Boal, C.W., Dykstra, C.R., Eds.; Island Press: Washington, DC, USA, 2018. [CrossRef]
9. Movalli, P.; Duke, G.; Helmick, K.; Katzner, T.; Krone, O.; Naidoo, V.; Pain, D.; Plaza, P.I.; Santangeli, A.; Taggart, M.; et al. Monitoring contaminants, emerging infectious diseases and environmental change with raptors, and links to human health. *Bird. Study* **2018**, *65* (Suppl. S1), S96–S109. [CrossRef]
10. Fischer, J.D.; Schneider, S.C.; Ahlers, A.A.; Miller, J.R. Urbanization and the predation paradox: The role of trophic dynamics in structuring vertebrate communities. *BioScience* **2012**, *62*, 809–818. [CrossRef]
11. Newton, I. *Population Ecology of Raptors*; Academic Press: London, UK, 1998.
12. Marzluff, J.M.; Ewing, K. Restoration of fragmented landscapes for the conservation of birds: A case study of urbanization and its effects on bird populations. In *Avian Ecology and Conservation in an Urbanizing World*; Marzluff, J.M., Bowman, R., Donnelly, R., Eds.; Springer: Boston, MA, USA, 2001; pp. 207–226.
13. Evans, K.L.; Davidson, S.C. The role of urban areas in the ecology of birds of prey. *Urban. Ecosyst.* **2014**, *17*, 795–807.
14. Shochat, E.; Warren, P.S.; Faeth, S.H.; McIntyre, N.E.; Hope, D. From patterns to emerging processes in mechanistic urban ecology. *Trends Ecol. Evol.* **2006**, *21*, 186–191. [CrossRef]
15. Bell, C.P.; Baker, S.W.; Parkes, N.G.; Brooke, M.D.L.; Chamberlain, D.E. The role of the Eurasian sparrowhawk (*Accipiter nisus*) in the decline of the house sparrow (*Passer domesticus*) in Britain. *Auk* **2010**, *127*, 411–420. [CrossRef]
16. McCabe, J.D.; Yin, H.; Cruz, J.; Radeloff, V.; Pidgeon, A.; Bonter, D.N.; Zuckerberg, B. Prey abundance and urbanization influence the establishment of avian predators in a metropolitan landscape. *Proc. R. Soc. B* **2018**, *285*, 20182120. [CrossRef] [PubMed]
17. Solonen, T. Larger broods in the Northern Goshawk *Accipiter gentilis* near urban areas in southern Finland. *Ornis Fenn.* **2008**, *85*, 118–125. Available online: https://ornisfennica.journal.fi/article/view/133712 (accessed on 1 March 2025).
18. Kettel, E.F.; Gentle, L.K.; Yarnell, R.W.; Quinn, J.L. The breeding performance of raptors in urban landscapes: A review and meta-analysis. *J. Ornithol.* **2018**, *159*, 1–18. [CrossRef]
19. Rosenfield, R.N.; Bielefeldt, J.; Rosenfield, L.J.; Cava, J.A. Nesting density, nest area reoccupancy, and monitoring implications for Cooper's Hawks in Wisconsin. *J. Raptor Res.* **1995**, *29*, 1. Available online: https://digitalcommons.usf.edu/jrr/vol29/iss1/1 (accessed on 1 March 2025).
20. Charter, M.; Izhaki, I.; Bouskila, A.; Leshem, Y. Breeding success of the Eurasian Kestrel (*Falco tinnunculus*) nesting on buildings in Israel. *J. Raptor Res.* **2007**, *41*, 139–143. [CrossRef]
21. Rutz, C. The establishment of an urban bird population. *J. Anim. Ecol.* **2008**, *77*, 1008–1019. [CrossRef]
22. Sumasgutner, P.; Nemeth, E.; Tebb, G.; Krenn, H.W.; Gamauf, A. Hard times in the city—Attractive nest sites but insufficient food supply lead to low reproduction rates in a bird of prey. *Front. Zool.* **2014**, *11*, 48. [CrossRef]
23. Leveau, L.M.; Gorleri, F.C.; Roesler, I.; González-Táboas, F. What makes an urban raptor? *Ibis* **2022**, *164*, 1213–1226. [CrossRef]

24. San Martín-Cruz, M.A.; Villegas-Patraca, R.; Martínez-Gómez, J.E.; Ruelas Inzunza, E. Raptors of a Neotropical city: Diversity and habitat relationships along an urbanization gradient. *Urban. Ecosyst.* **2024**, *27*, 927–940. [CrossRef]
25. Jones, M.P.; Pierce, K.E., Jr.; Ward, D. Avian vision: A review of form and function with special consideration to raptors. *J. Exot. Pet. Med.* **2007**, *16*, 69–87. [CrossRef]
26. Martin, G.R. Through birds' eyes: Insights into avian sensory ecology. *J. Ornithol.* **2012**, *153* (Suppl. 1), 23–48. [CrossRef]
27. Martin, G.R. Avian vision. *Curr. Biol.* **2022**, *32*, R1079–R1085. [CrossRef] [PubMed]
28. Ruggeri, M.; Major, J.C.; McKeown, C.; Knighton, R.W.; Puliafito, C.A.; Jiao, S. Retinal Structure of Raptor Revealed by Ultra-High Resolution Spectral-Domain Optical Coherence Tomography. *Investig. Ophthalmol. Vis. Sci.* **2010**, *51*, 5789–5795. [CrossRef]
29. Tella, J.L.; Hiraldo, F.; Donázar-Sancho, J.A.; Negro, J.J. Costs and benefits of urban nesting in the Lesser Kestrel. In *Raptors in Human Landscapes: Adaptations to Built and Cultivated Environments*; Bird, D.M., Varland, D.E., Negro, J.J., Eds.; Academic Press: London, UK, 1996; pp. 53–60.
30. Mazumdar, S.; Ghose, D.; Saha, G.K. Foraging strategies of Black Kites (*Milvus migrans govinda*) in urban garbage dumps. *J. Ethol.* **2016**, *34*, 243–247. [CrossRef]
31. Krone, O.; Altenkamp, R.; Kenntner, N. Prevalence of *Trichomonas gallinae* in Northern Goshawks from the Berlin area of Northeastern Germany. *J. Wildl. Dis.* **2005**, *41*, 304–309. [CrossRef] [PubMed]
32. Gargiulo, A.; Russo, T.P.; Caputo, V.; Cozza, D.; Zapparoli, G.; Fioretti, A.; Pagnini, U. Occurrence of enteropathogenic bacteria in raptors in Italy. *Lett. Appl. Microbiol.* **2018**, *66*, 202–206. [CrossRef]
33. Panter, C.T.; White, R.L.; Coutts, S.; Lindsell, J.A.; McDonald, R.A.; Bearhop, S. Causes, temporal trends, and the effects of urbanization on admissions of wild raptors to rehabilitation centers in England and Wales. *Ecol. Evol.* **2022**, *12*, e8856. [CrossRef]
34. Sol, D.; Santos, D.M.; GarcÍa, J. Competition for food in urban pigeons: The cost of being juvenile. *Condor* **1998**, *100*, 298–304. [CrossRef]
35. Padgett, D.; Glaser, R. How stress influences the immune response. *Trends Immunol.* **2003**, *24*, 444–448. [CrossRef]
36. Bocelli, M.L.; Morelli, F.; Benedetti, Y.; Leveau, L. Estrategias de escape de aves en ambientes urbanos. *El Hornero* **2022**, *37*, 7. [CrossRef]
37. Cade, T.J.; Martell, M.; Redig, P.; Septon, G.; Tordoff, H. Peregrine falcons in urban North America. In *Raptors in Human Landscapes: Adaptations to Built and Cultivated Environments*; Bird, D.M., Varland, D.E., Negro, J.J., Eds.; Academic Press: London, UK, 1996; pp. 3–13.
38. Riegert, J.; Fainová, D.; Bystrická, D. Genetic variability, body characteristics and reproductive parameters of neighbouring rural and urban common kestrel (*Falco tinnunculus*) populations. *Popul. Ecol.* **2010**, *52*, 73–79. [CrossRef]
39. Kolnegari, M.; Conway, G.J.; Basiri, A.A.; Panter, C.T.; Hazrati, M.; Rafiee, M.S.; Ferrer, M.; Dwyer, J.F. Electrical components involved in avian-caused outages in Iran. *Bird. Conserv. Int.* **2020**, *31*, 364–378. [CrossRef]
40. Batyrova, K.I.; Valieva, G.M. To the issue of involuntary confinement of raptor in the conditions of Almaty zoo. *Nauka I Mir.* **2016**, *1*, 111–112.
41. Pfander, P.V. Semi-species and unrecognized, hidden hybrids (on the example of raptor). *Raptors Their Conserv.* **2011**, *23*, 74–105.
42. Berezovikov, N.N. Winter encounter of the Black-eared Kite Milvus migrans lineatus in the city of Almaty. *Russ. J. Ornithol.* **2014**, *23*, 3981.
43. Berezovikov, N.N. On nesting of Kestrel *Falco tinnunculus* in dacha houses of Ust-Kamenogorsk. *Russ. J. Ornithol.* **2018**, *27*, 3394–3396.
44. Tarasovskaya, N.E. Grey Crow and Common Kestrel Nesting in Magpie Nests on the South-Eastern Steppe Outskirts of Pavlodar. 2022. Available online: https://repo.kspi.kz/bitstream/handle/123456789/5963/konf-14-04-22_150-156.pdf?sequence=1&isAllowed=y (accessed on 1 March 2025).
45. McDermid, S.S.; Winter, J. Anthropogenic forcings on the climate of the Aral Sea: A regional modeling perspective. *Anthropocene* **2017**, *20*, 48–60. [CrossRef]
46. Wang, X.; Chen, Y.; Li, Z.; Fang, G.; Wang, F.; Liu, H. The impact of climate change and human activities on the Aral Sea Basin over the past 50 years. *Atmos. Res.* **2020**, *245*, 105125. [CrossRef]
47. Khaibullina, Z.; Amantaikyzy, A.; Ariphanova, D.; Temirbayeva, R.; Mitusov, A.; Zhurumbetova, Z. Socio-economic and public health impacts of climate change and water availability in Aral District, Kyzylorda Region, Kazakhstan. *Asian J. Water Res.* **2022**, *8*, 177–204. [CrossRef]
48. Kassymova, S.; Yegemberdiyeva, S.; Mustafayev, K. Environmental and socio-economic aspects of sustainable development in Kyzylorda Region. *Econ. Ser. Bull. L.N. Gumilyov ENU* **2023**, *23*, 9–26. [CrossRef]
49. Sihanova, N.S.; Sultankulov, B.; Toleubayev, S.; Zhumadilov, Z.; Sultangazina, M.; Kassenova, N.; Kassenov, M.; Zhakupov, T.; Zhumabayev, M.; Zhanabergenov, K.; et al. New data on avifauna of the city of Kyzylorda (Kazakhstan). *Mod. Probl. Ornithol. Sib. Cent. Asia* **2022**, *208*, 1–15.

50. Kasimgaliev, S.; Kelinbaeva, R.; Sultanov, M.; Zhunisbekova, N. Geoinformation support, analysis, evaluation and forecasting of the use of land resources of Kyzylorda region. *Bull. L.N. Gumilyov Eurasian Natl. Univ. Chem. Geogr. Ecol. Ser.* **2023**, *144*, 105–118. [CrossRef]
51. Mukhamedzhanov, M.; Arystanbaev, Y.; Iskakov, N.; Kazanbaeva, L.; Bekzhigitova, D. Prospects of use of underground waters torangesicle field of water supply for the growing needs of Kyzylorda. *Int. Multidiscip. Sci. GeoConf. SGEM* **2017**, *17*, 659–667. [CrossRef]
52. Kassymgaliyev, S.; Turganaliyev, S.; Kaliyeva, M.; Dabylova, B.; Kozhakhmetov, B.; Khamit, N.; Zhumakan, A. Information support for the use of land resources in the Kyzylorda region, Kazakhstan: Analysis, assessment and forecasts. *Casp. J. Environ. Sci.* **2024**, *22*, 987–992. [CrossRef]
53. Dukenov, Z.; Rakhimzhanov, A.; Akhmetov, R.; Dosmanbetov, D.; Abayeva, K.; Borissova, Y.; Trushin, M. Reforestation potential of tugai forests in the floodplains of Syr Darya and Ili Rivers in the territory of Kazakhstan. *SABRAO J. Breed. Genet.* **2023**, *55*, 1768–1777. [CrossRef]
54. Schulz, C.; Kleinschmit, B. Monitoring the Condition of Wetlands in the Syr Darya Floodplain—How Healthy Are the Tugai Forests in Kazakhstan? *Forests* **2023**, *14*, 2305. [CrossRef]
55. Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan. Population Size and Migration. 2025. Available online: https://stat.gov.kz/ru/region/kyzylorda/ (accessed on 1 March 2025).
56. Nyussupova, G.N.; Isolde, B.; Kairova, S.G.; Kenespayeva, L.B. Social indicators of the quality of life of the population of the Republic of Kazakhstan: Analysis and evaluation. *J. Geogr. Environ. Manag.* **2019**, *52*, 48–56. [CrossRef]
57. Salnikov, V.; Talanov, Y.; Polyakova, S.; Assylbekova, A.; Kauazov, A.; Bultekov, N.; Musralinova, G.; Kissebayev, D.; Beldeubayev, Y. An Assessment of the Present Trends in Temperature and Precipitation Extremes in Kazakhstan. *Climate* **2023**, *11*, 33. [CrossRef]
58. Moyroud, N.; Portet, F. Introduction to QGIS. In *QGIS and Generic Tools*; Baghdadi, N., Mallet, C., Zribi, M., Eds.; Wiley-ISTE: London, UK; Hoboken, NJ, USA, 2018; pp. 1–17. [CrossRef]
59. MAPS.ME. Offline Maps GPS Nav. 2025. Available online: https://play.google.com/store/apps/details?id=com.mapswithme.maps.pro (accessed on 1 March 2025).
60. Conway, C.J.; Garcia, V.; Smith, M.D.; Hughes, K. Factors affecting detection of burrowing owl nests during standardized surveys. *J. Wildl. Man.* **2008**, *72*, 688–696. [CrossRef]
61. Berthiaume, E.; Bélisle, M.; Savard, J. Incorporating detectability into analyses of population trends based on hawk counts, a double-observer approach. *Condor* **2009**, *111*, 43–58. [CrossRef]
62. Dowling, J.L.; Luther, D.A.; Mara, P.P. Comparative effects of urban development and anthropogenic noise on bird songs. *Behav. Ecol.* **2011**, *23*, 201–209. [CrossRef]
63. Hogg, J.R. Habitat Associations of Raptors in Urban Business Parks. Master's Thesis, University of Missouri, Columbia, MO, USA, 2013.
64. Google Earth. 2025. Available online: https://earth.google.com/web/ (accessed on 1 March 2025).
65. Klausnitzer, B. *Ecology of Urban Fauna*; Springer: München, Germany, 1990; p. 246. [CrossRef]
66. MacKenzie, D.I.; Nichols, J.D.; Royle, J.A.; Pollock, K.H.; Bailey, L.L.; Hines, J.E. *Occupancy Estimation and Modeling: Inferring Patterns and Dynamics of Species Occurrence*; Academic Press: San Diego, CA, USA, 2006; p. 648.
67. Hansen, C.P.; Millspaugh, J.L.; Rumble, M.A. Occupancy modeling of ruffed grouse in the Black Hills National Forest. *J. Wildl. Man.* **2011**, *75*, 71–77. [CrossRef]
68. U.S. Department of the Interior. United States Geological Survey Patuxent Wildlife Research Center PRESENCE53. 2012. Available online: http://www.mbr-pwrc.usgs.gov/software/presence.html (accessed on 1 March 2025).
69. Duren, K.R.; Buler, J.J.; Jones, W.; Williams, C.K. An improved multi-scale approach to modeling habitat occupancy of northern bobwhite. *J. Wildl. Man.* **2011**, *75*, 1700–1709. [CrossRef]
70. Kroll, A.J.; Duke, S.D.; Runde, D.E.; Arnett, E.B.; Austin, K.A. Modeling habitat occupancy of orange-crowned warblers in managed forests of Oregon and Washington, USA. *J. Wildl. Man.* **2007**, *71*, 1089–1097. [CrossRef]
71. Henneman, C.; Andersen, D.E. Occupancy patterns of nesting-season habitat associations of red-shouldered hawks in central Minnesota. *J. Wildl. Man.* **2009**, *73*, 1316–1324. [CrossRef]
72. Bosakowski, T.; Smith, D.G. Distribution and species richness of a forest raptor community in relation to urbanization. *J. Raptor Res.* **1997**, *31*, 26–33.
73. Miller, J.R.; Hobbs, R.J. Conservation where people live and work. *Conserv. Biol.* **2002**, *16*, 330–337. [CrossRef]
74. Smallwood, J.A.; Wargo, P.J. Nest site habitat structure of American kestrels in northwestern New Jersey. *Bull. NJ Acad. Sci.* **1997**, *42*, 7–10.
75. Snep, R.P.H. Biodiversity Conservation at Business Sites—Options and Opportunities. Ph.D. Thesis, Alterra, Wageningen University & Research, Wageningen UR, Wageningen, The Netherlands, 2009.
76. MacKenzie, D.I.; Bailey, L.L. Assessing the fit of site occupancy models. *J. Agric. Biol. Environ. Stat.* **2004**, *9*, 300–318. [CrossRef]

77. Bennett, C. Evaluating the Influence of Habitat on Nest Distribution and Breeding Performance of the Marsh Harrier, *Circus aeruginosus*, in the UK. Ph.D. Thesis, Department of Life Sciences, Imperial College London, Silwood Park, UK, 2014.
78. Palomino, D.; Carrascal, L.M. Habitat associations of a raptor community in a mosaic landscape of Central Spain under urban development. *Landsc. Urban. Plan.* **2007**, *83*, 268–274. [CrossRef]
79. Bibby, K.; Jones, M.; Marsden, S. *Field Expeditionary Survey Methods: Bird Surveys and Records*; Translation from English; Russian Bird Conservation Union: Moscow, Russia, 2000; p. 186.
80. Dickinson, E.C.; Remsen, J.V., Jr. *The Howard Moore Complete Checklist of the Birds of the World*, 4th ed.; JSTOR: Ann Arbor, MI, USA, 2013; Volume 1.
81. Del Hoyo, J.; Collar, N.J. *HBW and BIRDLIFE International Illustrated Checklist of the Birds of the World*; Aves Press: London, UK, 2003; Volume 1.
82. Village, K. Breeding performance of kestrels at Eskdalemuir, South Scotland. *J. Zool.* **1986**, *208*, 367–378. [CrossRef]
83. Kostrzewa, A.A.; Kostrzewa, A.R. Der Bruterfolg des Turmfalken *Falco tinnunculus* in Deutschland: Ergebnisse 1985–1994 (Breeding success of the kestrel *Falco tinnunculus* in Germany: Results 1985–1994). *J. Ornithol.* **1997**, *138*, 73–82. [CrossRef]
84. Sumasgutner, P.; Schulze, C.H.; Krenn, H.W.; Gamauf, A. Conservation related conflicts in nest-site selection of the Eurasian Kestrel (*Falco tinnunculus*) and the distribution of its avian prey. *Landsc. Urban. Plan.* **2014**, *127*, 94–103. [CrossRef]
85. Rejt, Ł. Peregrine Falcon and Kestrel in urban environment—The case of Warsaw. In *Naturschutz und Verhalten*; Gottschalk, E., Barkow, A., Muehlenberg, M., Settele, J., Eds.; UFZ-Bericht: Leipzig, Germany, 2001; pp. 81–85.
86. Salvati, L. Spring weather and breeding success of the Eurasian Kestrel (*Falco tinnunculus*) in urban Rome, Italy. *J. Raptor Res.* **2002**, *36*, 15. Available online: https://digitalcommons.usf.edu/jrr/vol36/iss1/15 (accessed on 1 March 2025).
87. Kübler, S.; Kupko, S.; Zeller, U. The kestrel (*Falco tinnunculus* L.) in Berlin: Investigation of breeding biology and feeding ecology. *J. Ornithol.* **2005**, *146*, 271–278. [CrossRef]
88. Sánchez-Zapata, J.A.; Carrete, M.; Gravilov, A.; Sklyarenko, S.; Donázar, J.A. Land use changes and raptor conservation in steppe habitats of Eastern Kazakhstan. *Biol. Conserv.* **2003**, *111*, 71–77. [CrossRef]
89. Ilyukh, M.P. Common Kestrel in the Predcaucasus. *Cauc. Ornithol. Bull.* **2009**, *21*, 64–134.
90. Shcherbakov, B.V.; Berezovikov, N.N. To the ecology of the Common Kestrel *Falco tinnunculus* in the Western Altai. *Russ. J. Ornithol.* **2011**, *20*, 895–902.
91. Lykov, E.L. Nesting of the Common Kestrel *Falco tinnunculus* in Palaearctic cities, a brief review. *Russ. J. Ornithol.* **2017**, *26*, 149–153.
92. Panchenko, S.G. New data on avifauna of *Semipalatinsk vicinities*. *Russ. J. Ornithol.* **2011**, *20*, 2545–2549.
93. Khromov, V.A.; Shupova, T.V. Biodiversity of avifauna of the right bank part of Semey city (Semipalatinsk). *Ecol. Monit. Biodivers.* **2018**, *1*, 148–152.
94. Kuryashkin, A.N. Birds of the city of Kurchatov and its environs. *Russ. J. Ornithol.* **2021**, *30*, 3919–3940.
95. Barashkova, A.; Smelansky, I.; Tomilenko, A.; Akentiev, A. Raptors of the Kazakh Upland—Indicators of steppe well-being. *Ibis* **2013**, *155*, 426–427. [CrossRef]
96. Kolbintsev, V.G. Winter sightings of the Steppe Eagle *Aquila nipalensis* in Southern Kazakhstan. *Russ. J. Ornithol.* **2015**, *24*, 3923.
97. Kovshar, V.A.; Karpov, F.F. On wintering of some birds from the Red Book of Kazakhstan on the eastern coast of the Caspian Sea in 2008–2019. *Russ. J. Ornithol.* **2020**, *29*, 2343–2349.
98. Karyakin, I.V. What is happening to the steppe eagle. *Steppe Bull.* **2011**, *33*, 30–34.
99. Khokhryakov, D.D. The reasons for the disappearance of raptor in Kazakhstan. *Student science-a look into the future.* **2023**, *26*, 445–447.
100. Almasieh, K.; Cheraghi, M.; Khani, A.; Shahi, T. Evaluation of habitat suitability and migratory paths of an endangered raptor, Steppe Eagle (*Aquila nipalensis*) in Iran. *Glob. Ecol. Conserv.* **2024**, *55*, e03236. [CrossRef]
101. Ram, M.; Gadhavi, D.; Sahu, A.; Srivastava, N.; Rather, T.A.; Modi, V.; Jhala, D. Aspects of Movement Ecology and Habitat Use of Migratory Raptors Using Satellite Telemetry from India to Central Asia. *Birds* **2024**, *5*, 487–508. [CrossRef]
102. Zuban, I.A.; Sokolov, A.A.; Kuznetsova, N.P.; Petrova, M.V. Avifaunistic observations and findings in the North Kazakhstan region. *Fauna Ural. Sib.* **2010**, *15*, 43–74.
103. Karpov, F.F.; Kovshar, V.A. Observations of wintering birds on the eastern coast of the Kazakhstan part of the Caspian Sea. *Russ. J. Ornithol.* **2017**, *26*, 3699–3704.
104. Gubin, B.M. Wintering bird surveys in the South Kazakhstan region. *Russ. J. Ornithol.* **2018**, *27*, 847–868.
105. Chalikova, E.S. Results of 20-year winter bird surveys at the Shardara reservoir (Kazakhstan). *Russ. J. Ornithol.* **2024**, *33*, 1916–1934.
106. Ydenberg, R.C.; Butler, R.W.; Lank, D.B. Effects of predator landscapes on the evolutionary ecology of routing, timing and molt by long-distance migrants. *J. Avian Biol.* **2007**, *38*, 523–529. [CrossRef]
107. Møller, A.P. Urban areas as refuges from predators and flight distance of prey. *Behav. Ecol.* **2012**, *23*, 1030–1035. [CrossRef]

108. Martin, T.E.; Zhumabayev, R.; Bekmansurov, R.; Bekmansurov, T.; Zhumabayev, M.; Chudinov, A. Bird records from the arid and semi-arid areas in southern Kazakhstan, 2009–2017. *Sandgrouse* **2018**, *40*, 53–74.
109. Kolarić, V. Habitat preferences of Common Kestrel *Falco tinnunculus* in Zagreb. Larus-Godišnjak Zavoda za ornitologiju. *Hrvat. Akad. Znan. Umjet.* **2018**, *53*, 7–18. [CrossRef]
110. Kaf, A.; Saheb, M.; Bensaci, E. Preliminary data on breeding, habitat use and diet of Common Kestrel, *Falco tinnunculus*, in urban area in Algeria. *Zool. Ecol.* **2015**, *25*, 203–210. [CrossRef]
111. Casagrande, S.; Nieder, L.; Di Minin, E.; La Fata, I.; Csermely, D. Habitat utilization and prey selection of the kestrel *Falco tinnunculus* in relation to small mammal abundance. *Ital. J. Zool.* **2008**, *75*, 401–409. [CrossRef]
112. Sheridan, K.; Monaghan, J.; Tierney, T.D.; Doyle, S.; Tweney, C.; Redpath, S.M.; McMahon, B.J. The influence of habitat edge on a ground nesting bird species: Hen harrier *Circus cyaneus*. *Wildl. Biol.* **2020**, *2*, 1–10. [CrossRef]
113. Arroyo, B.; Amar, A.; Leckie, F.; Buchanan, G.M.; Wilson, J.D.; Redpath, S. Hunting habitat selection by hen harriers on moorland: Implications for conservation management. *Biol. Conserv.* **2009**, *142*, 586–596. [CrossRef]

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.