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Comparative Habitat Divergence and Fragmentation Analysis of Two Sympatric Pheasants in the Qilian Mountains, China

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Citation: Xie, W.-D.; Jia, J.; Song, K.; Bu, C.-L.; Ma, L.-M.; Wang-Jie, G.-S.; Li, Q.-L.; Yin, H.-Q.; Xu, F.-Y.; Ma, D.-F.; et al. Comparative Habitat Divergence and Fragmentation Analysis of Two Sympatric Pheasants in the Qilian Mountains, China. *Land* **2022**, *11*, 2104. https://doi.org/10.3390/land11122104

Academic Editors: Stephen Blake and Francesco M. Angelici

Received: 15 September 2022
Accepted: 15 November 2022
Published: 22 November 2022

Abstract: Habitat fragmentation is considered a major threat to biodiversity worldwide. Two endangered species, the blood pheasant (*Ithaginis cruentus*) and the blue eared pheasant (*Crossoptilon auritum*), coexist in a fragmented forest in the Qilian Mountains. However, how their habitats react to the fragmenting landscape remains unclear. Therefore, we carried out a field survey in the core habitat of the two species in Qilian Mountains National Park and used the MaxEnt Model to predict their potential distribution and to assess the protection efficiency. Then, we utilized a modified within-patch fragmentation categorizing model to identify how their functional fragmentations differentiated. The results showed that the habitat utilization of the two pheasant species was significantly different, with a potential distribution area of 18,281 km^2 for the blood pheasant and 43,223 km^2 for the blue eared pheasant. The habitat of the blue eared pheasant is highly fragmented with 27.7% categorized as 'Interior' and 49.3% as 'Edge', while the habitat of the blood pheasant is more severe with 2.1% categorized as 'Interior' and 50.4% as 'Edge'. Analysis shows that large areas of habitat for the two pheasants remain unprotected by the Qilian Mountains National Park. The intense grazing and human infrastructure may have a large effect on the currently highly fragmented landscape. Future measurements are needed to alleviate this conflict.

Keywords: blue eared pheasant; blood pheasant; human interference; MaxEnt; protected areas; sympatric species

1. Introduction

Habitat fragmentation is considered a major threat to biodiversity worldwide [1]. Human-related land-use change, i.e., agricultural expansion and urbanization, is rapidly fragmenting the natural ecosystem and causing biodiversity loss, especially in China [2]. Therefore, habitat fragmentation assessment has become crucial in wildlife protection [3]. However, research showed that the reaction of wildlife habitat to climate change and human influence is species-specific, even for sympatric ones [4,5], indicating the necessity to understand how endangered species react to environmental conditions specifically when designing targeted protection strategy.

Nature reserves or national parks are effective solutions for in-suit biodiversity protection. Established in 2017, Qilian Mountains National Park (QMNP) has served as an isolated refuge for many gallinaceous birds during the Pleistocene glaciations, such as the Chinese grouse (*Tetrastes sewerzowi*), the blood pheasant (*Ithaginis cruentus*) and the blue eared pheasant (*Crossoptilon auritum*) [6]. QMNP is located in one of the biodiversity hotspots where many endemic species have habituated and, therefore, it is prioritized for biodiversity conservation in China [7,8]. The QMNP protects the core breeding habitat for two endangered Galliformes species, namely the blood pheasant and the blue eared pheasant [9,10], which are unique genetic resources for whole populations like the Chinese grouse [6,11]. The blood pheasant prefers coniferous or mixed forests and scrub at 2100–4600 m above sea level (ASL) [12,13]. The blue eared pheasant is a rare species endemic to China, distributed in the mountainous regions of Qinghai, Gansu, and Sichuan provinces and the Ningxia Hui Autonomous Region [14,15].

Many avian species have suffered from human activities, as man-made infrastructure have cut through and fragmented their habitat [16]. Gallinaceous birds, which are ground-dwelling with limited disperse ability [5,17–19], are particularly vulnerable to human over-exploiting and infrastructure expansion. The blood pheasant and the blue eared pheasant are listed as second class national protected animals in China, which are threatened by non-sustainable harvest and trade, as well as destruction and degradation of the forests [20]. Recently, the field work from Zhang et al. showed the sympatric and weakly connected landscape pattern of the blood pheasant and the blue eared pheasant [9] in the Qilian Mountain National Nature Reserve, Gansu, China. Their results also showed an urgent need to quantify the habitat fragmentation in the extensive range of the Qilian Mountains.

In this study, we carried out a field line transect survey and camera-trapping in the Qilian Mountains to study the threads and causes for habitat loss and fragmentation of the blood pheasant and the blue eared pheasant. Camera-trapping has been widely used in wildlife conservation and it has been successfully used to detect rare or elusive species for evaluating the effectiveness of protected area management [21]. Then, we utilized species distribution modeling (SDM), a widely used method to evaluate the geographical distribution of species, to evaluate the potential distribution range and ecological niche divergence of the two species. Finally, we utilized a modified forest fragmentation analytical model [5,22] to assess and quantify species-specific responses to habitat fragmentation and within-patch functional habitat fragmentation categorization. By quantifying the extent of fragmentation of their geographical distribution, we intend to clarify how this pair of sympatric species responds differently to human interference and how well the two pheasants are protected in QMNP.

2. Materials and Methods

2.1. Study Area

The study area includes the QMNP and the Qilian basin (Figure 1), which is located in the northeast of the Qinghai-Tibet Plateau (QTP), with a total area of 221,067 km^2 and a typical plateau continental climate, which is characterized by low annual mean temperatures (most areas below 0 °C) and high sunshine durations exceeding 2800 h. This makes the study area unique in terms of hydrothermal conditions [23]. Elevation throughout the Qilian Mountains Area ranges from 1623 m to 5766 m ASL. The Qilian Mountains are surrounded by the Gobi Desert and has important water sources and many inland rivers, such as the Shiyanghe River, Heihe River, and Shulehe River [24,25]. The area is covered with diverse vegetation due to its unique geographical features and the edge effect of flora (Figure A1) [26]. We included the Qilian Mountains and the Qilian basin in a polygon range based on features of the geography, like mountains and rivers.

2.2. Field Study

In 2021, from 26 April to 2 May, we carried out a systematic transect survey along with camera-trapping in the core habitat of the blood pheasant and the blue eared pheasant in the Qilian Mountains (Figure A2). The total length of the 76 line transects in our survey is 99.97 km. Camera-trapping was designed to be equally separated for at least 1 km and to be sampled at sites with trails or sightings of blood pheasant and blue eared pheasant. All the photos taken during the monitoring period (from 26 April to 28 June) were examined and selected to identify blood pheasant and blue eared pheasant.

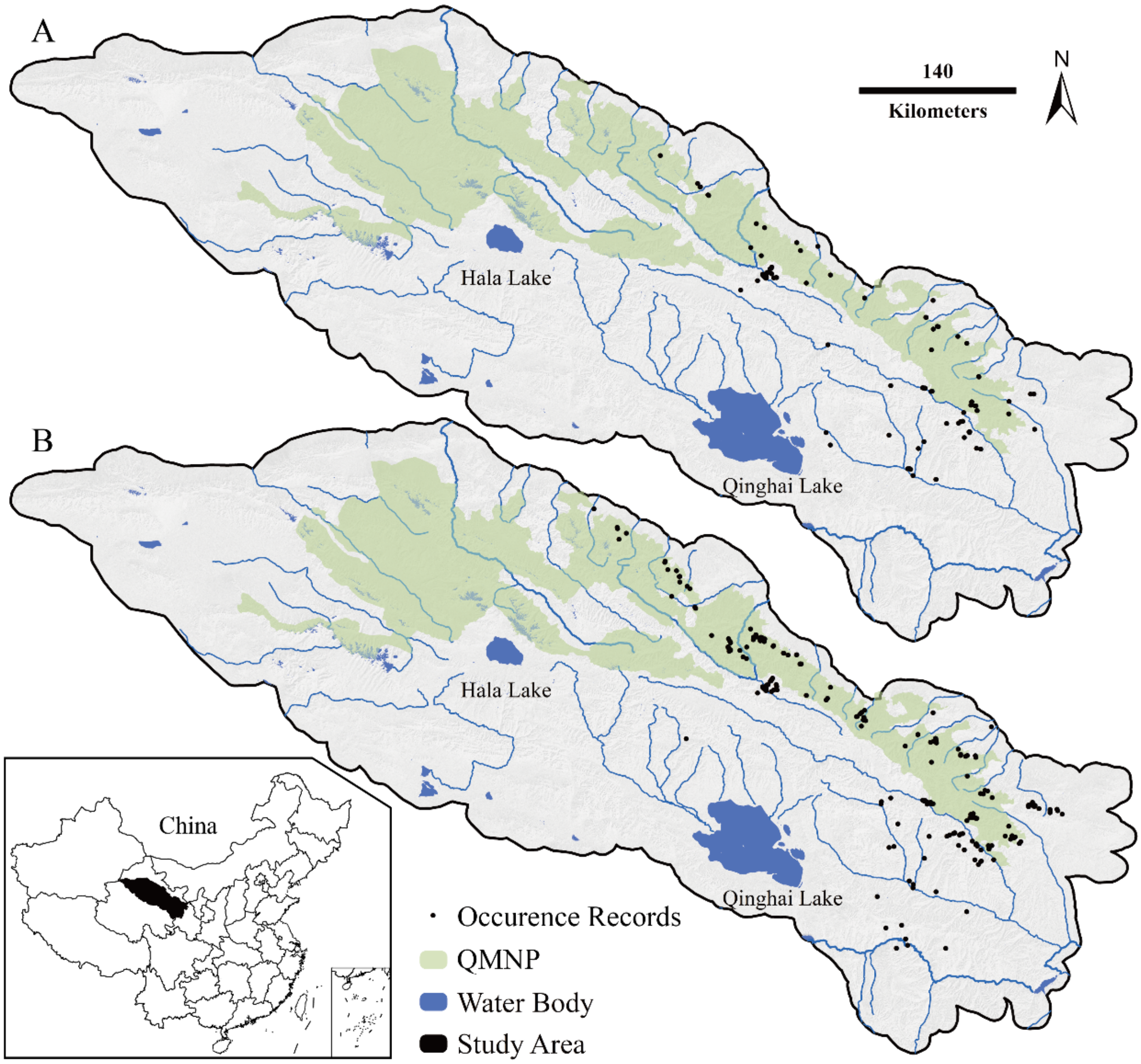

Figure 1. Species occurrence sites (the black spots) for blood pheasant (**A**) and blue eared pheasant (**B**). The range of the QMNP is highlighted in green. The administrative border of China was derived from the Standard Map Service: GS(2019)1686.

2.3. Occurrence Data

We collected the occurrence data for blood pheasants and blue eared pheasants from the transect survey, camera-traps, previous surveys, and online database (Table A1). We used data from previous surveys and online data from the Global Biodiversity Information Facility (GBIF, www.gbif.org, accessed on 23 June 2021). Considering the data from the GBIF database may be biased or misidentified, we carefully examined every record and checked every location using Google Earth. In order to account for spatial autocorrelation between species occurrence points, we added a 300 m buffer area around each species occurrence point using ArcGIS 10.7 (Esri, Redlands, CA, USA) [27]. In total, 105 different samples for blood pheasant and 85 samples for blue eared pheasant were obtained (Table A2).

2.4. Environmental Variables

To get a more informative result for this small-scaled study area, only high-resolution (30 m) environmental variables were used, including three topographic factors, five Euclidean distance factors, and the Land Use and Land Cover variables, in the species distribution model (Table 1). Altitude, aspect of slope, and slope layers were retrieved from the ASTER GDEM 30M product from the USGS. Cropland and lake distribution layers were extracted from the land use and land cover layers from GLC FC30-2020 [28]. The distribution of rivers was accessed from the global HydroRIVERS Version 1.0 dataset. The road dataset was accessed from Gaode Map and building data was downloaded from GHSL (ghslsys.jrc.ec.europa.eu). Cropland, lake, river, road, and building layers were then imported to ArcGIS 10.7 as sources for calculating Euclidean distance variables. The same geographic extent (30 m cell size) and projected coordinate system (WGS 1984 UTM Zone 48N) were selected for each layer. Correlation testing was performed for all 9 environmental variables in R and we found no strong correlation, according to the Cohen 1988 correlation rule (Figure A3) (Very Small: $|r| \leq 0.1$; Small: $0.1 < |r| \leq 0.3$; Moderate: $0.3 < |r| \leq 0.5$; Strong: $|r| > 0.5$) [29].

Table 1. Environmental variables used in the models.

Type	Variable	Description	Unit	Source
Topographic variables	Altitude Aspect Slope		m ° °	ASTER_GDEM_30M, From: https://earthexplorer.usgs.gov/ (Accessed on 23 June 2021)
Land cover variables	LULC	Land Use and Land Cover	-	GLC_FCS30-2020, From: http://data.casearth.cn/sdo/detail/5d904b7a0887164a5c7fbfa0 (Accessed on 10 July 2021)
Euclidean distance factor	Cropland	Distance to croplands	m	
	Lake	Distance to lakes	m	
	River	Distance to rivers	m	River data from https://hydrosheds.org/page/hydrorivers (Accessed on 11 July 2021)
	Road	Distance to roads	m	Gaode Map
	Building	Distance to buildings	m	GHSL, From: https://ghslsys.jrc.ec.europa.eu/download.php (Accessed on 10 July 2021)

2.5. Model Building and Evaluation

We conducted SDM in MaxEnt version 3.4.4, an adapted and developed software using the maximum entropy general-purpose machine learning method [30–32], which is known to outperform other methods due to its extremely small sample size tolerance in a variety of wildlife studies [32–35]. Combining presence-only data with the environmental constraints presented as GIS layers in ASCII form, we modeled the potential distribution of the blood pheasant and the blue eared pheasant using the ten-fold subsampled method with default settings and a maximum of 5000 iterations.

We selected Jackknife analysis to evaluate the modeling contributions of each environmental value and we used Cohen's kappa statistic [36], the area under the curve (AUC) of receiver operating characteristics (ROC), and true skills statistics (TSS) to validate the performance of the models. A Cohen's kappa statistic ≤ 0 indicates a prediction no different from one that is random, whereas +1 stands for perfect performance. AUC values are threshold-independent measures of model accuracy, where an AUC value of 0 indicates a model with no better discrimination than chance, whereas an AUC value > 0.8 indicates excellent discrimination. TSS compares the number of correct predictions, minus the predictions attributed to random guessing, against a hypothetical set of ideal predictions. TSS values range from -1 to +1, where values ≤ 0 indicate a prediction no different from one that is random. A value of +1 represents perfect performance but is not affected by the prevalence or size of the validation dataset [5].

2.6. Data Analysis

To understand whether there is habitat selection differentiation between the blood pheasant and the blue eared pheasant, environmental values were extracted for each presence location and an ANOVA (Analysis of Variation) test was performed for each pair of environmental variables (for categorical variables—land use and land cover—we performed the Fisher *t*-test).

Then, the logistic output of the species distribution models (0–1) were transformed into binary maps (0 and 1) using the Equate Entropy of Thresholded and Original Distributions Logistic Threshold [37] for each species that exhibited the largest TSS and kappa value. The binary distribution maps for each species were projected onto WGS 1984 UTM Zone 48N in ArcGIS 10.7 and were used for habitat fragmentation analysis and protection GAP analysis in QMNP.

The dispersal ability of the blood pheasant can be up to 2.2 km [5], thus we used 0.5 km, 1 km, 1.5 km, 2 km, and 2.5 km as dispersal distances in habitat fragmentation analysis. Because of the lack of data on the blue eared pheasant's maximum dispersal distance, the dispersal distance of its closely related species *C. manchuricum* is referred to, which is 5.97 km [38], and intercepted as 3 km, 4 km, 5 km, 5.5 km, and 6 km to calculate the habitat fragmentation matrices.

We calculated four class-level metrics using FRAGSTATS v4.2.1.603 [39] to evaluate the habitat fragmentation of blood pheasants and blue eared pheasants with different dispersal distances, including: (1) number of patches (NP), which indicates the degree of fragmentation [40]; (2) largest patch index (LPI), which represents the percentage of the landscape comprised of the largest habitat patch with high connectivity [41]; (3) percentage of the landscape (PLAND), which quantifies the habitat patches with high connectivity as a percentage of the study area [42]; and (4) area-weighted mean radius of gyration (GYRATE_AM) or correlation length (CL), which provides a measurement of the extensiveness of the habitat patches with high connectivity [43]. These metrics have been used frequently in research [44–46].

Finally, we distinguished different functional fragmentations into six fragmentation categories using two measurements, namely the amount of habitat (Pf) and its occurrence in adjacent pixels (Pff). These were calculated in fixed-sized 'windows' devised from a forest fragmentation analytical model by Riitters et al. [22] (Interior: $Pf = 1.0$; Patch: $Pf < 0.4$; Transitional: $0.4 \leq Pf < 0.6$; Edge: $Pf \geq 0.6$ and $Pf > Pff$; Perforated: $Pf \geq 0.6$ and $Pf < Pff$; Undetermined: $Pf \geq 0.6$ and $Pf = Pff$). Since no single scale or window size is deemed suitable for all species across all habitats [5,22,47], we selected a 9×9-pixel window as the smallest practical scale (highest resolution) needed to reliably estimate forest cover (Pf) and functional response identification. The process was conducted using MATLAB version 2021b and the distinguished functional fragmentation was displayed in ArcGIS.

The 'Interior' refers to the area where all of the grids are habitable in the habitable sampling window. According to percolation theory, a connectable path can be formed when a certain type of grid reaches 60% of the sampling range, that is, when the proportion of suitable grids (or unsuitable grids) reaches 60% of the sampling window [22]. Therefore, $Pf < 0.4$ is the criterion for the non-diffusible habitat (named, 'Patch'). When $Pf \geq 0.6$, $Pff > Pf$ indicates that the distribution of suitable rasters is adjacent and accounts for a relatively large proportion, indicating that the window position should be in the 'Edge'. When $Pff < Pf$, it means that the distribution of non-suitable rasters is concentrated and the proportion is larger, representing a non-suitable raster with clustered distribution in the range of suitable habitat and is thus defined as 'Perforated'. Finally, the areas that fall between 'Perforated' and 'Patch' are defined as 'Transitional'.

3. Results

3.1. Model Validation

Model performance suggested further analysis can be performed, with all mean AUC > 0.9, kappa > 0.4, and TSS > 0.7. According to the Jackknife analysis (Figure A4), the variables Land Use and Land Cover have the highest gains in all of the modeling processes, which therefore suggests that they are the most important predictors for the distribution of blood pheasants and blue eared pheasants, while Aspect has little contribution to the modeling process (Table 2). For kappa and TSS, the values of every model and every threshold were calculated, which is 0.1147 for blood pheasant and 0.1768 for blue eared pheasant.

Table 2. Percent contribution for each variable and differentiation test for each pair of variables. Variables were ranked by contribution percentage to the models.

	Blood Pheasant		Blue Eared Pheasant	
Variable	**Rank**	**Contribution (%)**	**Rank**	**Contribution (%)**
LULC ***	1	63.6	1	41.3
Discropland	2	9.3	2	28.1
Disbuildings ***	3	9.1	4	2.7
Altitude **	4	7.6	3	21.6
Disroads ***	5	4.5	8	0.7
Disriver ***	6	3	5	2
Slope	7	1.2	9	0.7
Dislakes ***	8	1.2	6	1.7
Aspect	9	0.5	7	1.1

*** $p < 0.01$; ** $p < 0.05$.

3.2. Potential Distribution and Niche Differentiation

The predicted geographical distribution of the blood pheasant and the blue eared pheasant mainly concentrate on the east part of the Qilian Mountains, with a total potential distribution area of 18,281 km^2 for the blood pheasant and 43,223 km^2 for the blue eared pheasant (Figure 2). Their distributions overlapped by 17,321 km^2, which is 94.7% of the total potential distribution area for the blood pheasant and 40.1% for the blue eared pheasant. According to the response curves, both the blood pheasant and the blue eared pheasant distributed around 3 km ASL, mostly within 5 km from cropland, and within 20 km from lakes (Figure 3). The response curve for aspect shows that the two pheasants favor the north slope slightly more than the south slope. Both the blood pheasant and the blue eared pheasant prefer habitats in broad-leaved and needle-leaved forests with slopes steeper than 15 degrees but differentiated in the distance to rivers, where blood pheasants relatively prefer to be closer to rivers (Figure 3). According to the result of the differentiation test, blood pheasants and blue eared pheasants show significant differentiation in altitude, distance to rivers, lakes, buildings, roads, and land use and land cover, whereas blood pheasants occupy a narrower altitude range and tend to be closer to rivers, lakes, buildings, and roads. No significant differentiation was found for slope, aspect, and distance to cropland (Table 2).

3.3. Habitat Fragmentation and Protection GAP

After determining the suitable areas of the blood pheasant and the blue eared pheasant, we divided them into 135 and 19 suitable patches according to their maximum diffusion distance, and found that the suitable patches of the blood pheasant were more separated than those of the blue eared pheasant. Large patches of predicted habitat for both species were primarily located in the southeast Qilian Mountains. With higher dispersal ability, NP decreases, whereas LPI, PLAND, and CL rise with higher dispersal ability (Table A3). For the blood pheasant, 7.9–13.4% of the landscape was occupied by connected habitat patches, compared to 20.0–24.0% for the blue eared pheasant, depending on different dispersal abilities. According to the calculated metrics, the habitat of the blood pheasant is noticeably more fragmented than that of the blue eared pheasant.

Our functional habitat categorization analysis revealed that the 'Interior' habitat category predicted for the blood pheasant, throughout all predicted suitable areas, is very limited; only 2.1% of suitable areas are categorized as 'Interior', 20.2% of its habitat categorized as 'Patch', 50.4% as 'Edge' areas, and 18.7% as 'Transitional'. In comparison, the blue eared pheasant had 27.7% of suitable areas are categorized as 'Interior', 7.6% of its habitat categorized as 'Patch', 49.3% as 'Edge' areas, and 8.0% as 'Transitional' (Figure 4). The 'Patch' and 'Transitional' habitats were relatively more proportionate in the predicted habitat of the blood pheasant, whereas the proportion of 'Edge' was similar between the two pheasants (Figure 4).

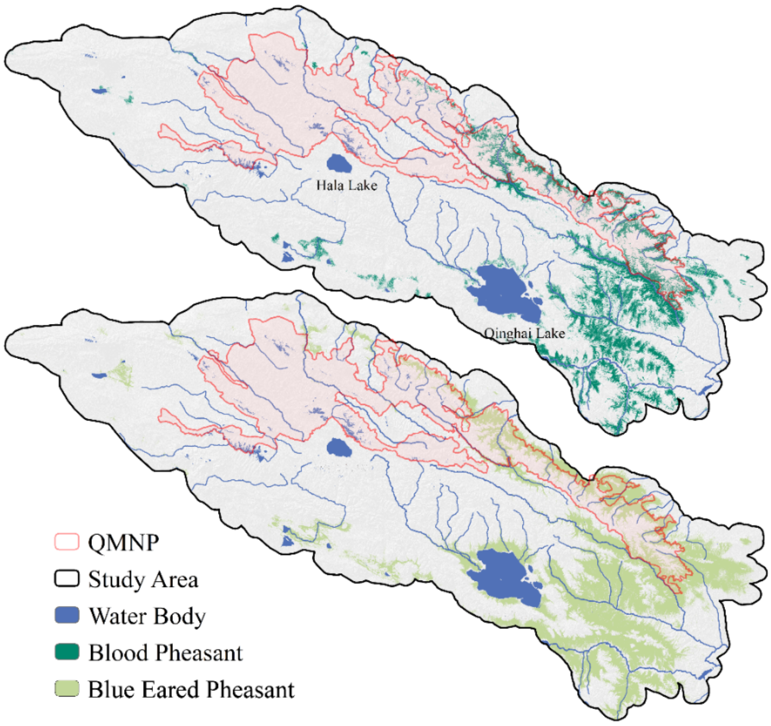

Figure 2. Binary map of the potential distribution of blood pheasants and blue eared pheasants. The range of the Qilian Mountains National Park (QMNP) is highlighted in red.

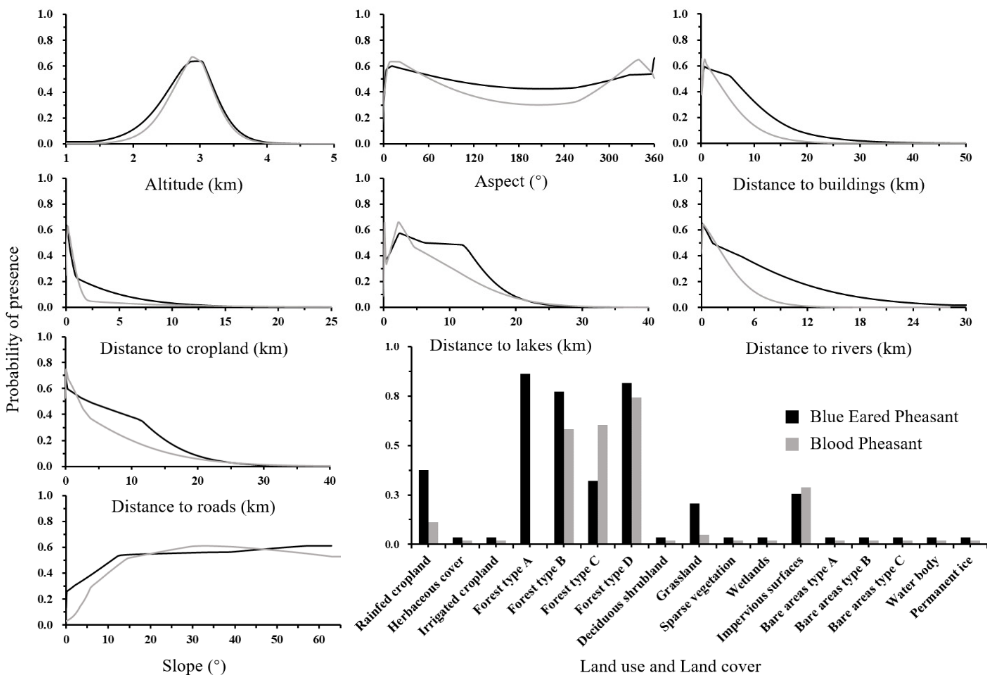

Figure 3. Probability of presence in reaction to different variables. Forest type A: closed evergreen broadleaved forest, forest type B: closed deciduous broadleaved forest, forest type C: open evergreen needle-leaved forest, forest type D: closed evergreen needle-leaved forest, bare areas type A: bare areas, bare areas type B: consolidated bare areas, bare areas type C: unconsolidated bare areas.

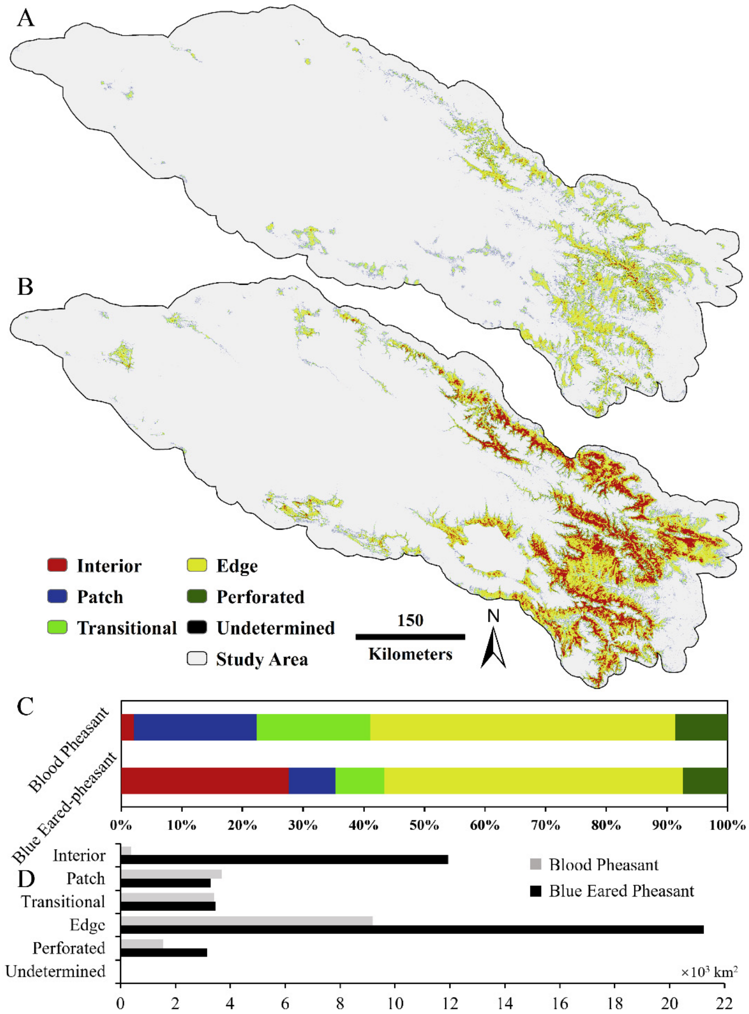

Figure 4. Functional habitat fragmentation categorization: (**A**) blood pheasant and (**B**) blue eared pheasant; (**C**) percentage of different habitat fragmentation and (**D**) total area of different habitat fragmentation.

The species distribution model showed that a major portion of the distribution of blood pheasants and blue eared pheasants falls outside of the Qilian NP. Only 22.9% of the blood pheasant's habitat is protected and in the range of the QMNP area, and only 17.6% for the blue eared pheasant. There is a large area of concentrated and connected habitat unprotected in the southeast Qilian Mountains, indicating a large protection gap for the two pheasants.

4. Discussion

The establishment of the QMNP is an important step taken to protect and restore the ecosystem and biodiversity of the area. Understanding the habitat status and how endemic species respond to habitat fragmentation in the Qilian Mountains can contribute to the future protection of wild animals in QMNP. In this study, we modeled the potential distribution and quantified the habitat fragmentation of blood pheasants and blue eared pheasants in the Qilian Mountains. Different from a previous study in the Gansu areas of the Qilian Mountains [9], we performed the analysis in a larger area with a different set of fine-scaled environmental variables. The SDM result showed extensive overlap between the blood pheasant and the blue eared pheasant, whereas their habitats are fragmented differently. Large areas of protection gaps for two pheasants were found that could promote the QMNP to serve a better role in protecting their fragmented habitats.

Our results revealed highly fragmented geographical patterns in the two pheasants, while blood pheasants had a smaller and more fragmented habitat with a minor percent of core habitat (namely, 'Interior') (Figure 4). The more limited dispersal distance and stricter habitat selection of the blood pheasant may cause habitat fragmentation. On the contrary, the broader spatial niche of the blue eared pheasant makes it more resilient to forest fragmentation which is also related to its broader food choice [48]. In the field study, we found that blood pheasants were more alert to human presence, with less activity in open areas and preferred the north slope, or shady slope, which may be caused by major forest growth on the shady slope or the north slope, due to relatively less evapotranspiration [49]. In addition, we found there are excessive pasture fences in the forest, disrupting the natural dispersal of pheasants and other ground-dwelling animals [50]. Since blood pheasants and blue eared pheasants both rely heavily on needle-leaved and broad-leaved forests (Figure 3), the extensive segmentation by fences may be another reason for the current landscape pattern of the two pheasants [18,19,23].

Over the last 20 years, rapid infrastructure development in China has had a severe impact on the habitats of endangered species, since the distance from their core habitat to the impervious infrastructure is shortening every year [16]. The response curves for both blood pheasants and blue eared pheasants indicated that the major sustainable habitats of the two pheasants fell within 10 km of transportation infrastructure (i.e., distance to roads) and built-up areas (i.e., distance to buildings) (Figure 3). The smaller extent of the blood pheasant's distribution may be related to their vicinity to human infrastructure. It seems that the two species of pheasants are well adapted to human infrastructure, even in their core habitat. Other studies regarding the brown eared pheasant (*Crossoptilon auritum*) and the Reeves's pheasant (*Syrmaticus reevesii*), also show that moderate human disturbance has a positive effect on their populations [51–53]. However, the capability of living near man-made infrastructure can be an ecological trap (i.e., habitats more or equally preferred, but with costs to fitness [54]) for both species. Moreover, areas that are more urbanized may not be included in a natural protecting zone, increasing the risk of further deteriorating their habitat.

For better conservation, it is crucial not only to protect the major habitats of these pheasants but also to prevent the continuous degradation of habitat fragmentation. The development of human infrastructure should be avoided around the species' core habitat and breeding zones. Future examination and systematic assessment of local biodiversity and its reaction to human interference (i.e., excessive fences) are needed. Based on the modeling of the blood pheasant and the blue eared pheasant, we suggest that more effort should be taken to protect areas exploited by humans but also habitable for wild animals.

5. Conclusions

In this study, we used SDM to model the geographical distribution of blood pheasants and blue eared pheasants, and used a modified analytical model to quantify their functional habitat fragmentations. We found that their habitats largely overlapped and were severely fragmented. Between them, the blood pheasant has a smaller and more fragmented habitat, which may be related to its stricter habitat selection and narrower food selection, as well as because of the extensive fences in the forest. Many of their habitats are located near human infrastructure and remain largely unprotected, with only 22.9% of blood pheasants' habitats being protected by the QMNP. By comparison, only 17.6% is protected for the blue eared pheasant. The future protection plan needs to alleviate the conflict between grazing and wildlife protection, while putting more effort in protecting wildlife habitats in human-exploited areas.

Author Contributions: Conceptualization, Y.-H.S., K.S. and Y.F.; methodology, K.S., X.-H.L. and W.-D.X.; software, K.S. and W.-D.X.; validation, Y.-H.S., K.S., Y.F. and J.J.; investigation, J.J., W.-D.X., C.-L.B., L.-M.M., G.-S.W.-J., Y.F., K.S., Q.-L.L., H.-Q.Y. and F.-Y.X.; resources, Y.-H.S., Y.F., D.-F.M. and K.S.; data curation, K.S.; writing—original draft preparation, W.-D.X.; writing—review and editing, Y.-H.S., K.S., W.-D.X., Y.F. and J.J.; visualization, W.-D.X.; supervision, Y.-H.S. and K.S.;

project administration, Y.-H.S.; funding acquisition, Y.-H.S. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded to Yue-Hua Sun by the Biodiversity Conservation Project of the Second Forest and Grass Ecosystem Recovery Funding in 2021 (funding number QHTX-2021-007).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Acknowledgments: We thank the Administration of Qilian National Park (including Long-term Scientific Base, Qinghai Service Center, Menyuan Management Division and Qilian Management Division) for their help during our field surveys.

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

Appendix A. Land Cover and Land Use

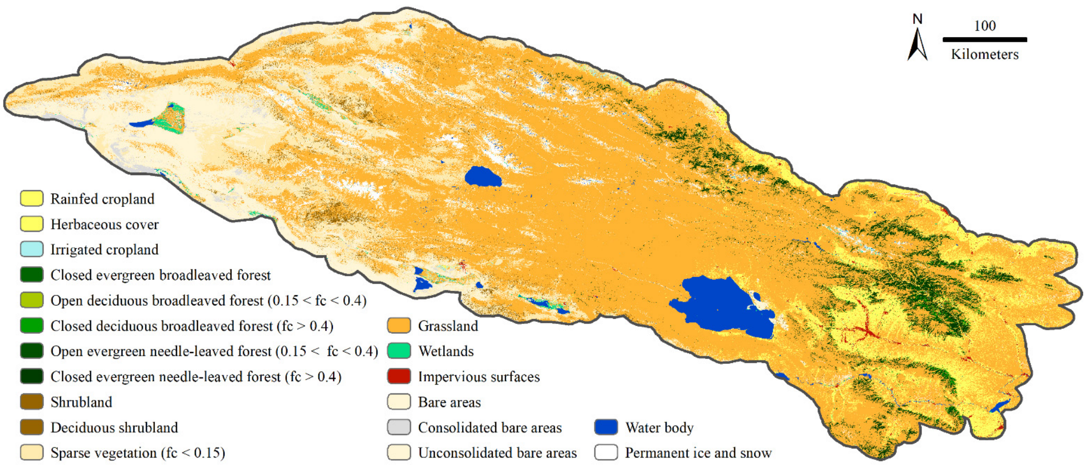

Figure A1. Land cover and land use in the study area.

Appendix B. Result of Field Study

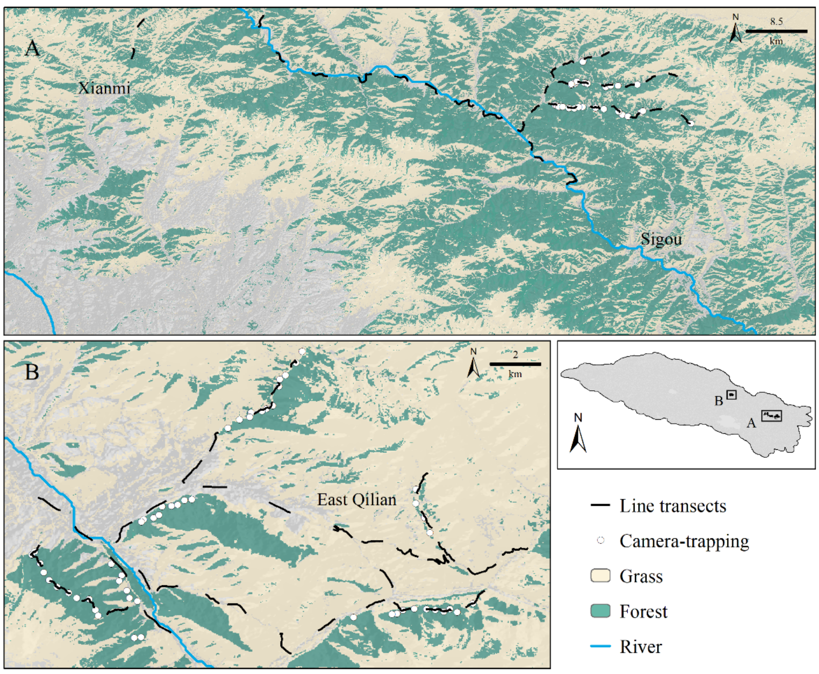

Figure A2. Location of line transects and camera-trapping in the Qilian Mountains. Field study was mainly carried out at Xianmi, Sigou (**A**) and East Qilian (**B**).

Appendix C. Correlation of Environmental Variable

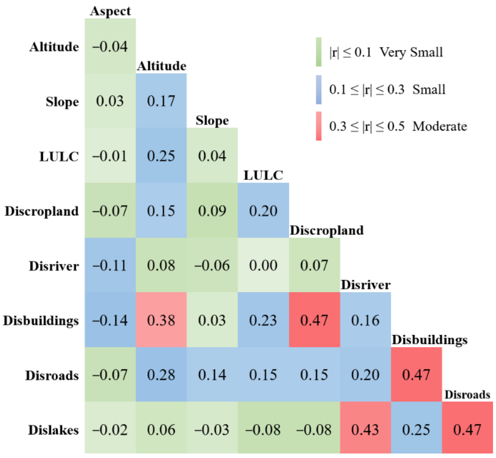

Figure A3. Pearson's correlation (r) test for every environmental variable using Cohen's 1988 rule to determine the significance level.

Appendix D. Occurrence Data Source

Table A1. Source of occurrence data used for the distribution modeling of the blood pheasant and the blue eared pheasant.

Species	Total	Selected	GBIF	Field Survey	Previous Studies
Blood Pheasant	196	172	30	105	37
Blue Eared Pheasant	263	258	55	85	118

Appendix E. Field Survey Result

Table A2. Result of line transect and camera-trap survey.

Survey Site	Survey Period	Total Cameras	No. of Blood Pheasant Obs.	No. of Blue Eared Pheasant Obs.
Xian-mi	26–27 April	16	14	16
Si-gou	28–29 April	27	9	13
East of Qilian country	30 April–2 May	57	87	56

Appendix F. Regularized Training Gain

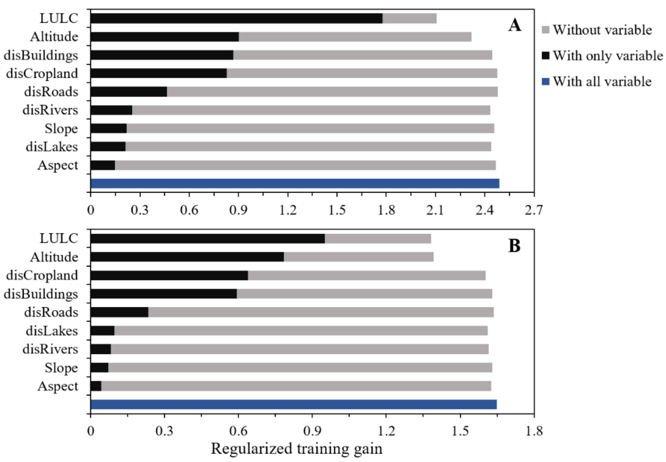

Figure A4. Regularized training gain for each variable for the blood pheasant (**A**) and the blue eared pheasant (**B**).

Appendix G. Fragmentation Analysis

Table A3. Ecological niche fragmentation analysis. NP: number of isolated patches; LPI: largest patch index; PLAND: percentage of the landscape; CL: correlation length (or GYRATE_AM: area-weighted mean radius of gyration).

Species	Dispersal Distance (km)	NP	LPI	PLAND	CL
Blood Pheasant	0.5	1699	5.08	7.82	62,591.64
	1	518	8.01	9.85	98,775.56
	1.5	266	9.22	11.27	103,526.01
	2	183	10.07	12.41	108,159.23
	2.5	135	10.78	13.39	109,810.40
Blue Eared Pheasant	3	43	16.10	20.03	127,128.70
	4	31	17.73	21.50	142,703.49
	5	23	20.41	22.78	163,100.33
	5.5	20	20.88	23.38	164,575.24
	6	19	21.28	23.96	165,054.78

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