Science Advances

Supplementary Materials for

Urbanization affects spatial variation and species similarity of bird diversity distribution

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The PDF file includes:

Figs. S1 to S8
Legends for tables S1, S2, and S5 to S7
Tables S3 and S4

Other Supplementary Material for this manuscript includes the following:
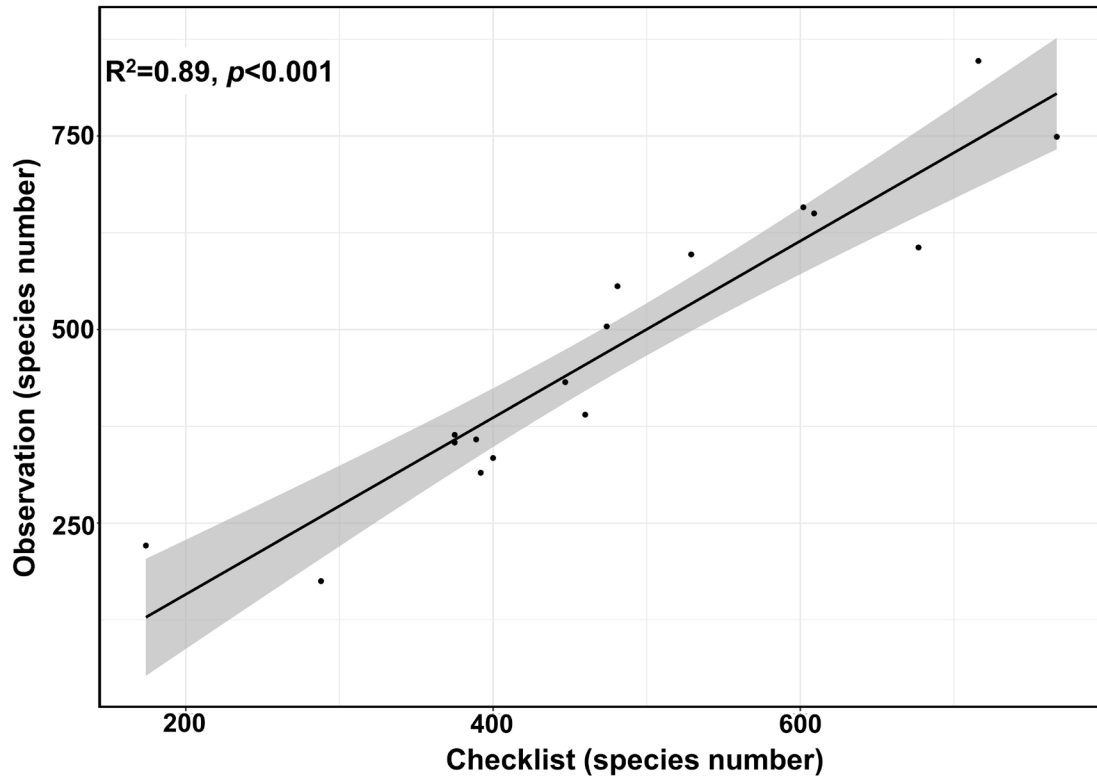
Tables S1, S2, and S5 to S7

Fig. S1 Species richness for observation data and checklist are significantly correlated in sub-biogeographic regions.
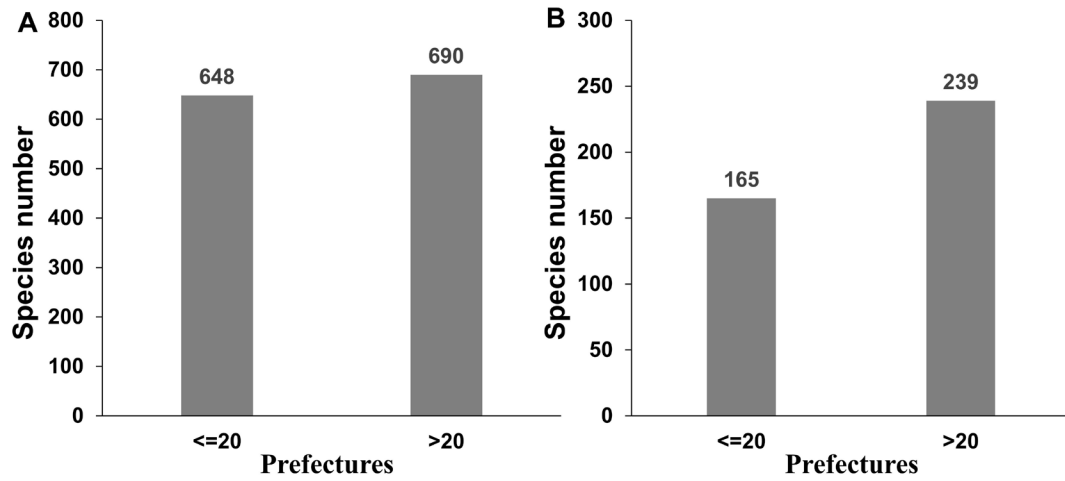
Fig. S2 Number of prefectures where birds are distributed. (A) For all birds, the number of species with distribution prefectures greater than 20 and less than 20 is very close. (B) For 404 bird species with expanded range, most can be observed in more than 20 prefectures.
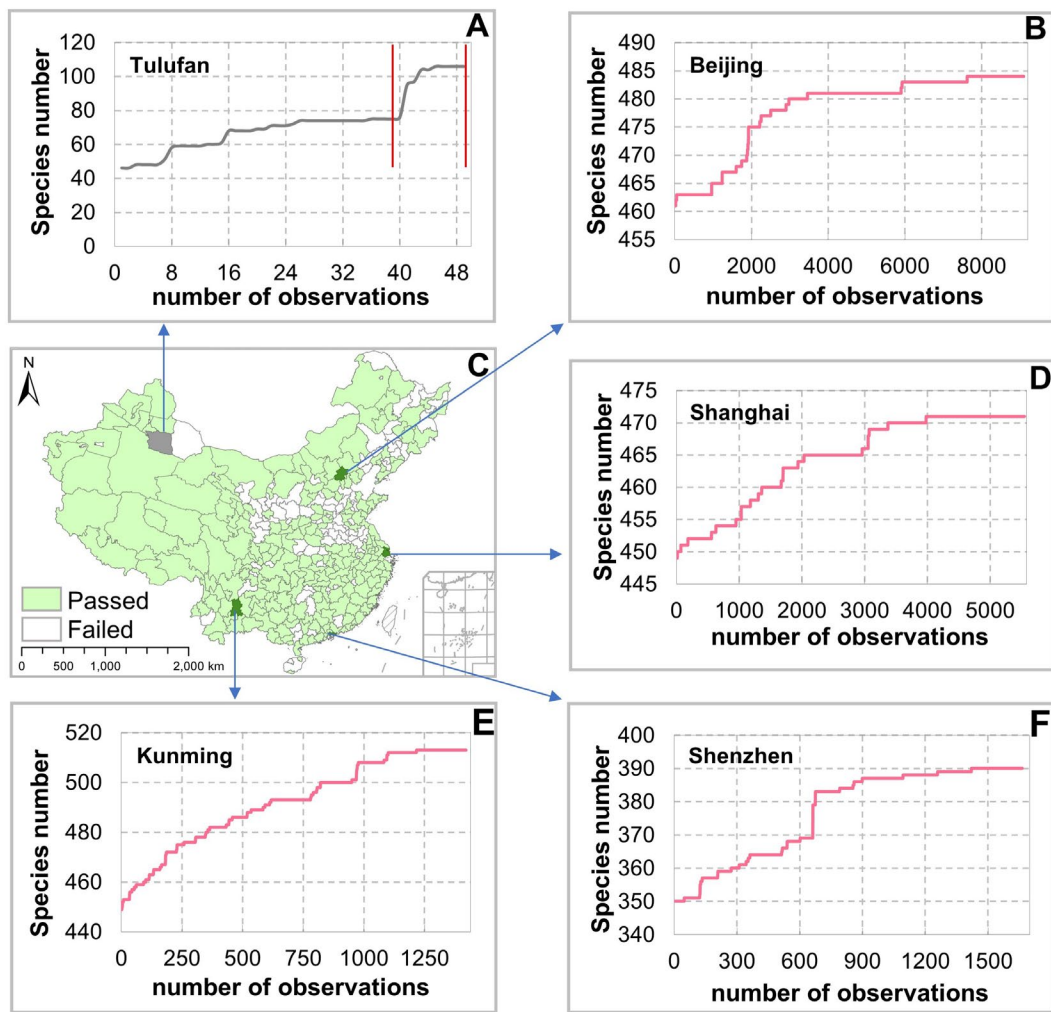
Fig. S3 Examples of data quality control at prefecture level. (A) Because the average increase in the number of bird species observed was more than 1% over the last 10 observations, Tulufan failed data quality control. (B) Beijing passed data quality control. (C) Light green represents prefectures passing data quality control, with a total of 247 prefectures passing through data quality control. (D) Shanghai, (E) Kunming, and (F) Shenzhen all passed data quality control.

Note: Because the bird species list for each prefecture is downloaded from the China Bird Report (*63*), and then supplemented by GBIF and eBird, the number of species does not start at 0.
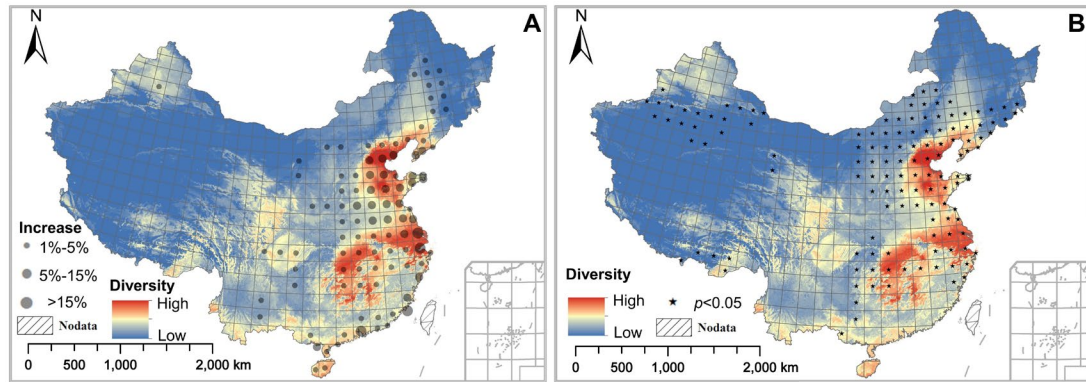
Fig. S4 The hotspots of urbanization expansion are significantly spatially correlated with the hotspots of climatically-based potential ranges of threatened birds. (A) The 'increase' represents the proportion of increase in impervious surface area from 2001 to 2018 within each 200km*200km grid. Nearly all the hotspots of climatically-based potential ranges of threatened birds are located in the hotspots of urbanization expansion. (B) The '*p*<0.05' means that the average number of threatened species and the proportion of impervious surface are spatially significantly correlated according to the results of the geographically weighted regression model (*42*).
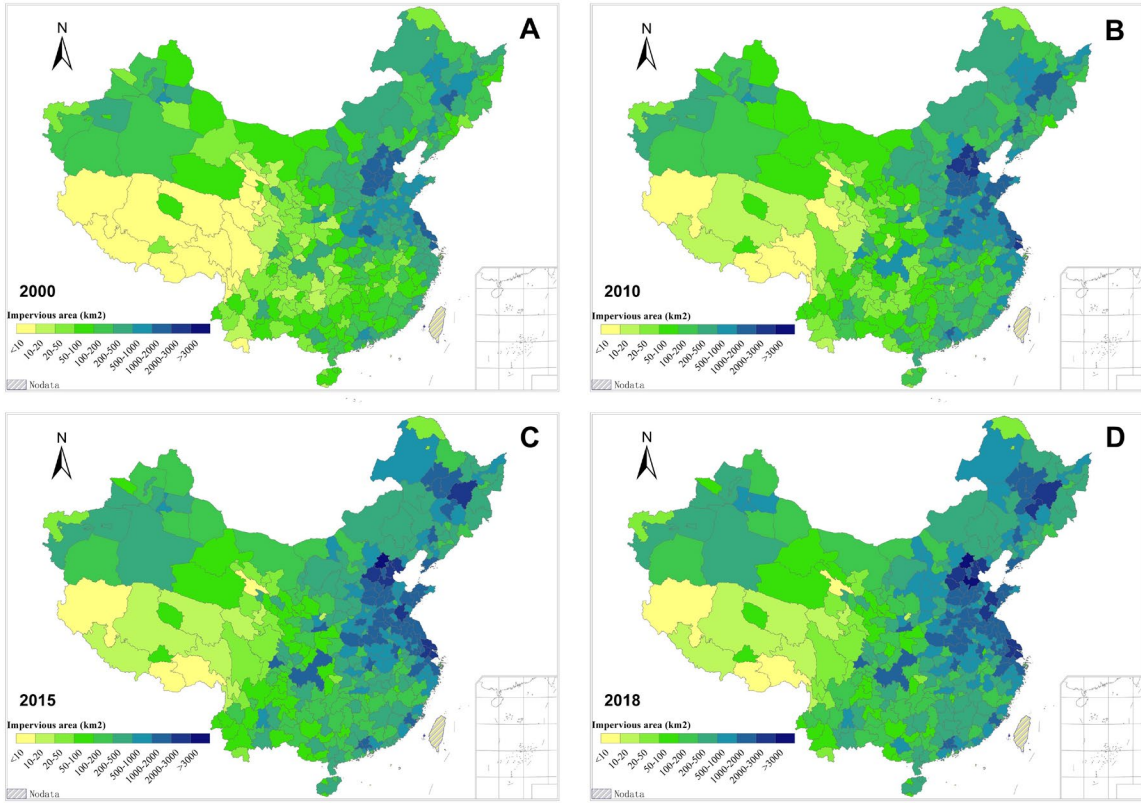
Fig. S5 Map of city-level aggregate impervious area in 2000(A), 2010(B), 2015(C) and 2018(D).
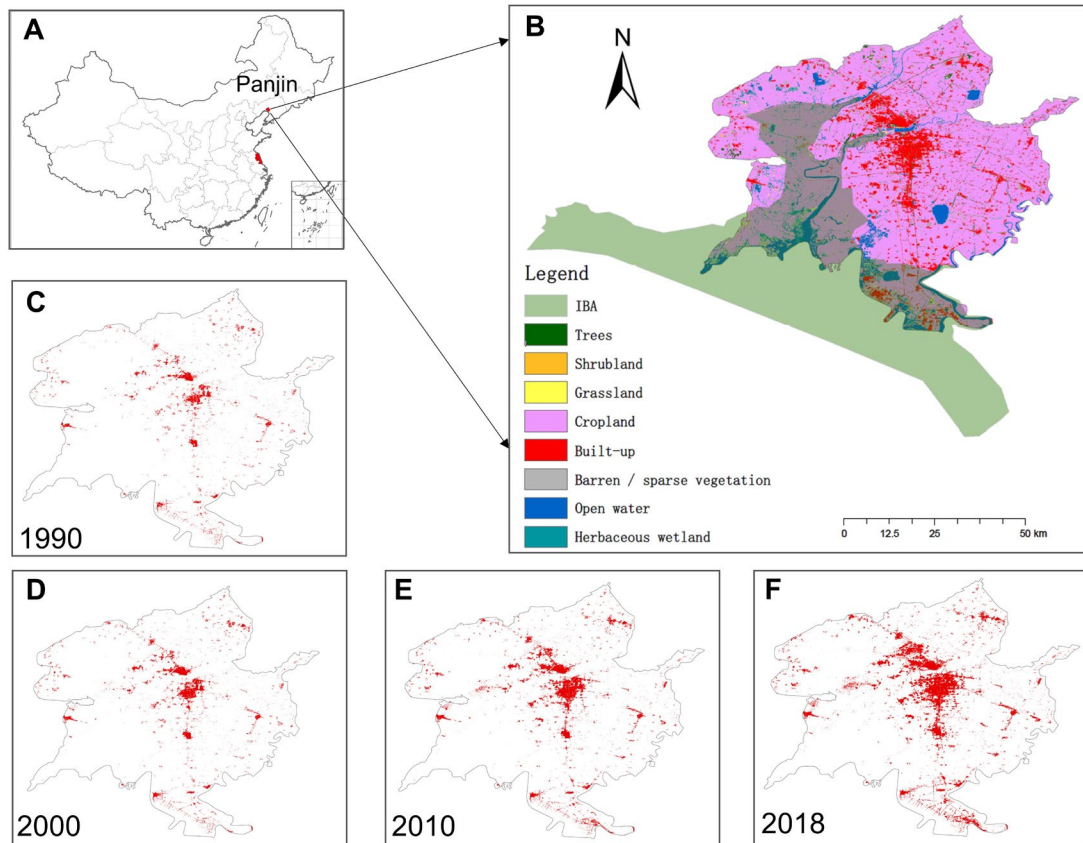
Fig. S6 The location of Panjin city and the increase of impervious surface in Panjin. (A) Panjin is an important passage for migratory birds located in Northeast China. (B) Southwest Panjin has a large area as Important Bird Area (IBA) (*52*). The basemap is land cover map for 2020 at 10 m resolution based on Sentinel-1 and Sentinel-2 data (*53*). (C) The impervious surface in Panjin in 1990. (D) The impervious surface in Panjin in 2000. (E) The impervious surface in Panjin in 2010. (F) The impervious surface in Panjin in 2020. Continued increase in impervious surface from 1990 to 2018 indicates rapid urbanization in Panjin.
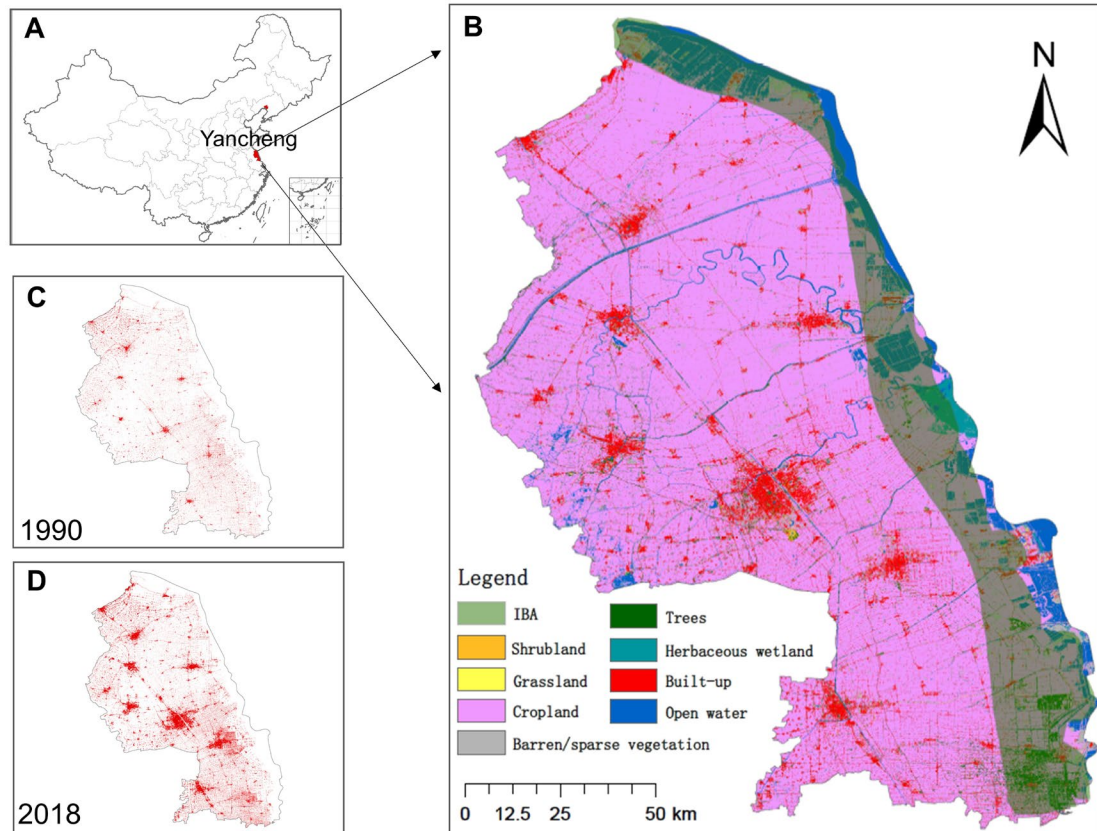
Fig. S7 The location of Yancheng city and the increase of impervious surface in Yancheng. (A) Yancheng is an important passage for migratory birds located on the east coast of China. (B) The entire coastal zone of Yancheng is Important Bird Area (IBA) (*52*). The basemap is land cover map for 2020 at 10 m resolution based on Sentinel-1 and Sentinel-2 data (*59*). (C) The impervious surface in Yancheng in 1990. (D) The impervious surface in Yancheng in 2020. Significant increase in impervious area from 1990 to 2018 indicates rapid urbanization in Yancheng.

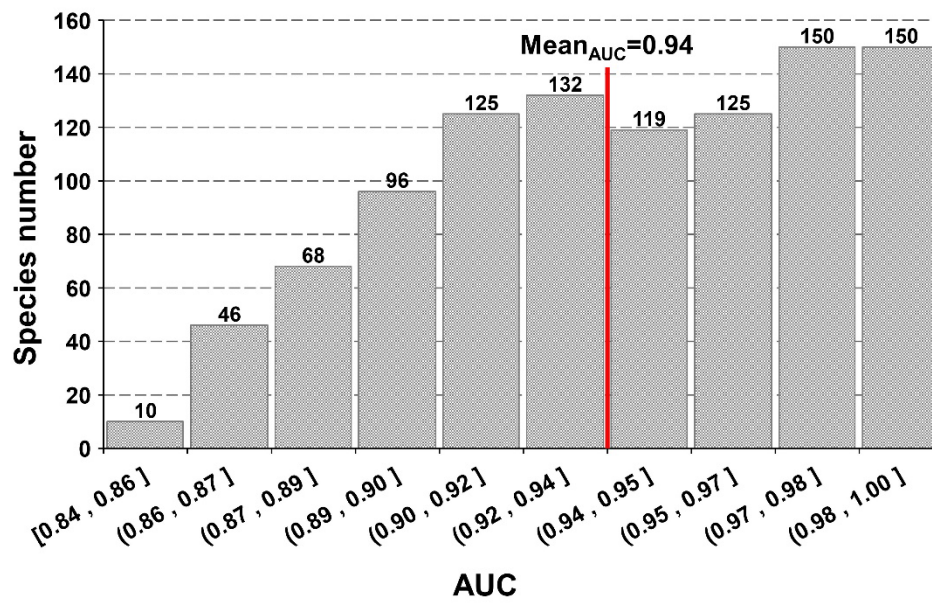**Fig. S8** Distribution of Area Under Curve (AUC) in different bird species. The SDMs for all 1021 species with more 50 records had good performance. The mean of AUC is 0.94. The AUC corresponding to each bird species can be obtained at table S6.

Table S1 The bird list of the distribution area has been expanded.

It cannot be embedded into the Word file and provided in Microsoft Excel format.

Table S2 Threatened bird list observed in coastal prefectures.

It cannot be embedded into the Word file and therefore is provided in Microsoft Excel format.

Table S3 Reclassification of landcover (MCD12Q1 V6) by major habitat type.

Habitat Type	Landcover in MCD12Q1 V6
Forests	Evergreen Needleleaf Forests
	Evergreen Broadleaf Forests
	Deciduous Needleleaf Forests
	Deciduous Broadleaf Forests
	Mixed Forests
Grasslands	Grasslands
Wetlands	Permanent Wetlands
	Water Bodies
Urbanbuilt	Urban and Built-up Lands
Others	Croplands
	Closed Shrublands
	Open Shrublands
	Woody Savannas
	Savannas
	Cropland/Natural Vegetation Mosaics
	Permanent Snow and Ice
	Barren
	Unclassified

Note: Considering that the main habitat types associated with urbanization are forest, grassland, wetland and built-up land, the International Geosphere–Biosphere Programme (IGBP) land use classification system in MCD12Q1 V6 product was reclassified. In the new land use classification, forests include evergreen needleleaf forest, evergreen broadleaf forest, deciduous needleleaf forest, deciduous broadleaf forest and mixed forest, wetland includes permanent wetland and water bodies, grassland is the same as grassland in IGBP, urbanbuilt represents the urban and built-up lands in IGBP. All other land use types in the IGBP are reclassified as others.

Table S4 Bird similarity network (BSN) between core cities based on birdwatching data and SDMs.

city1_id	city1_name	city2_id	city2_name	similar based on birdwatching data	similar based on SDMs
1101	Beijing	3101	Shanghai	0.69	0.63
3101	Shanghai	4401	Guangzhou	0.63	0.56
1101	Beijing	4401	Guangzhou	0.48	0.37

Table S5 The bird list of this study.

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Table S6 Prefecture-level spatial distribution of bird in China mainland.

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Table S7 AUC of the SDMs for each bird species.

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