Dynamic Changes in Overwintering Population Size and Habitat Distribution of Red-crowned Cranes in Northern Jiangsu (Postprint)

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Abstract

An in-depth investigation was conducted utilizing data tracking and historical land use change data to examine the spatiotemporal responses of overwintering population dynamics and habitat distribution of red-crowned cranes in the Subei region since documented records began. Results indicate that during the early 1980s, the overwintering population of red-crowned cranes was widely distributed throughout the Subei region, particularly in the inland lakes and marshes of the middle and lower Yangtze River, as well as the coastal tidal flat wetlands of Jiangsu Province. Following the 1990s, the distribution range gradually shifted toward coastal tidal flat wetlands, primarily concentrated within Sheyang County of Yancheng City. In the 21st century, the distribution has become focused in the core zone of the Yancheng National Nature Reserve for Rare Birds. Concurrently, the overwintering population size has undergone a marked decline, decreasing by over 50% compared to the 1990s. The changes in overwintering population size and habitat distribution are correlated with land use patterns and anthropogenic disturbances surrounding habitat sites, with habitat area loss and landscape fragmentation identified as the primary drivers of population reduction.

Full Text

Preamble

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Dynamic Changes in Population Size and Habitat Distribution of Wintering Red-crowned Crane in Northern Jiangsu Province

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Abstract

The red-crowned crane (*Grus japonensis*), a globally endangered species, receives first-grade state protection in China. The global wild population comprises approximately 3,050 individuals. Recently, the western flyway subpopulation of red-crowned crane has declined sharply. Previous studies have primarily focused on population size, distribution, and habitat selection, with several further examining the effects of human disturbance. However, most such studies concentrated on the coastal regions of Yancheng, Jiangsu Province over short time periods, with few addressing long-term historical tracking of wintering populations and their behaviors.

Using trace data and land-use data available over a comparatively long period, this study systematically analyzed the dynamic changes in population size and habitat distribution of wintering red-crowned cranes since 1982, revealing the effects of land-use changes on wintering habitats. The results yield three main conclusions. First, the wintering population has changed substantially from 1982 to 2015, with current population size 50% lower than that recorded in the 1990s. Second, the range of wintering habitats has gradually reduced, and remaining habitats have become severely fragmented. The red-crowned crane prefers various types of wetlands in winter. During the 1980s, the species was widely distributed in northern Jiangsu, particularly in swamps around island lakes in the middle and lower reaches of the Yangtze River, as well as in the coastal wetlands of Jiangsu. Over following decades, wintering habitats gradually shifted to coastal areas, primarily distributed in Sheyang County, Yancheng. However, with increasing development of the coastal economy at the beginning of the twenty-first century, wintering habitats in coastal areas were further reduced and fragmented. At present, wintering red-crowned cranes are concentrated in the central area of the Yancheng National Nature Reserve. Third, according to Pearson correlation analysis, habitat distribution points of wintering red-crowned cranes are significantly related to land-use types and socio-economic development. Rapid economic development in China, accompanied by rapid

expansion of land use for construction and industry, directly decreased the area of wintering habitat. Additionally, changes in the distribution and intensity of land use and human disturbance caused existing habitats to become fragmented, reducing their suitability as wintering habitat for red-crowned cranes.

Keywords: landscape ecology; red-crowned crane; population size; habitat types; dynamic change

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1. Study Area Selection

The study area selected was the northern region of Jiangsu Province in the lower Yangtze River basin (hereinafter referred to as northern Jiangsu), which serves as the concentrated wintering ground for the western flyway population of red-crowned cranes. This region covers an area of approximately [area] with annual precipitation of [precipitation]. The area features a mild climate, representing a transitional zone from temperate to subtropical climate with moderate rainfall (13–16°C, 724–1210 mm). Due to the low-lying terrain, the unique muddy coastal tidal flats along the coast have become the primary wintering habitat for red-crowned cranes and other bird species.

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2. Methods for Obtaining Red-crowned Crane Population and Distribution Data

National surveys of red-crowned cranes in China began in [year]. Due to the lack of large-scale unified national survey data, population size and distribution could only be obtained through literature review. Specifically, articles were retrieved from Chinese journal databases and Web of Science using [search terms] as subject and keywords, with county-level statistical units used for analysis. To ensure data comparability, information on crane distribution habitats and population sizes mentioned in the literature was compiled by year. When recording habitat distribution locations and population numbers, priority was given to literature conducting professional surveys of crane habitats and populations, while descriptive data from different authors for the same region were used only as general references.

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3. Methods for Obtaining Red-crowned Crane Habitat Type Data

This study utilized Jiangsu Province land-use datasets from the 1980s, 1995, 2005, and 2015, sourced from the Earth System Science Data Sharing Platform (Yangtze River Delta sub-platform). Data sources included [original data], updated using 2015 Gaofen-1 remote sensing imagery and field survey data. Since

the study area is the region north of the Yangtze River in Jiangsu Province, geometric correction of each period' s imagery was performed using the Yangtze River as a boundary, followed by boundary clipping and landscape reclassification to obtain land-use type maps for each period. To achieve spatial matching, the WGS-1984 geographic coordinate system was adopted. All vector data layers were converted and topology processing was conducted on landscape type data using ArcGIS 10.0 for assignment and statistical calculations, yielding landscape type distribution maps for each period.

To understand and recognize red-crowned crane wintering habitat types and their distribution from a landscape ecology perspective, historical land-use data were summarized and reclassified. The landscape reclassification system is shown in Table 1. Landscape type maps from each period were overlaid in the environment, and indices reflecting habitat landscape changes were selected, including patch area, mean patch area, and aggregation index, to extract red-crowned crane habitat information and obtain the number and area of habitat patch types. Fragstats 4.4 software was used for statistical analysis of changes in crane habitat distribution points and influencing factors, and SPSS 22.0 was used for correlation analysis.

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1. Dynamic Changes in Red-crowned Crane Wintering Population and Distribution in Northern Jiangsu

The wintering population of red-crowned cranes in northern Jiangsu experienced a fluctuating change process. According to historical records, cranes were widely distributed in coastal counties and cities of Jiangsu Province except Gaoyou City and Hongze County. Early records of crane distribution included Xiangshui County and Dongtai County, with population numbers of [numbers]. From 1985–1988, the wintering crane population increased to 1,128 individuals, accounting for approximately half of the global wild red-crowned crane population. From 1991–1995, the population size decreased to around [number]. By 2000, the population numbered [number], and since then, the wintering crane population has shown a gradually decreasing trend, with numbers remaining at approximately four to five hundred individuals annually.

The fluctuating changes in red-crowned crane numbers in northern Jiangsu are closely related to habitat distribution changes. The wintering habitat distribution area has continuously changed. According to records, during the 1980s, red-crowned cranes were widely distributed in inland lake marshes and coastal tidal flats north of the Yangtze River in Jiangsu, with population numbers reaching over one thousand. During this period, wintering habitats were mainly concentrated in Sheyang County, Dafeng County, and Dongtai County, with scattered distributions in Xiangshui County and Binhai County. From 1991–1995, some crane habitats began to be lost, with small populations in Binhai County and Dongtai County, and no crane distribution recorded in Guannan County and

Rudong County. From 2000–2005, the distribution range further contracted, with wintering habitats mainly distributed in Sheyang County, Dafeng County, and Dongtai County, and small numbers in Xiangshui County. Sheyang County became the concentrated wintering distribution area for cranes. After 2005, wintering habitats were mainly distributed in coastal Sheyang County and Dafeng County, with small populations in Xiangshui County and Dongtai County. By 2011–2015, no cranes were recorded in Dongtai County, and wintering habitats further shrank, with the wintering area concentrated in Sheyang County.

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2. Spatiotemporal Characteristics and Trends of Red-crowned Crane Habitat Changes

Wild red-crowned cranes are highly sensitive and have stringent habitat quality requirements. By overlaying historical crane distribution locations on corresponding land-use maps and enlarging these distribution points, we found that cranes preferentially select locations with low vegetation coverage, minimal human disturbance, and shallow water areas for foraging or roosting during winter. Their habitat types tend to be saline marsh and reed marsh wetlands, with clear water areas generally distributed around roosting or foraging sites. Cranes are also sensitive to human disturbance and generally avoid areas with frequent human activity.

The main wintering habitat types and characteristics of red-crowned cranes are shown in Table 3. Analysis of habitat distribution changes reveals that: 1) During the 1980s–1990s, red-crowned crane wintering habitats were mainly lake shore beaches and reed marshes with minimal human disturbance, widely distributed around inland lakes in the middle and lower reaches of the Yangtze River, such as lakeshore reed marshes around Gaoyou Lake or Hongze Lake. In coastal areas, wintering habitat types included reed beaches, aquaculture ponds, and salt pans with minimal human activity. 2) With increasing land-use intensity and human disturbance, areas around inland lakes became unsuitable for cranes, and wintering habitats gradually shifted to coastal counties and cities. 3) In the 2000s, crane habitats were widely distributed in coastal tidal flats, but habitat distribution points gradually decreased. 4) After 2010, wintering habitats were mainly concentrated within Sheyang County in Yancheng City, with distribution patterns changing from continuous to fragmented.

Statistical analysis of crane wintering habitat distribution points shows that habitat distribution points have been gradually lost since 1982, decreasing from [number] to [number]. The changing trend is shown in Figure 2. Further analysis of crane wintering habitat types and their changes reveals that during the study period, the area of lakeshore beaches around inland lakes decreased from 1,525.6 km² in the 1980s to 1,343.53 km² in 2015, while the number of patches also decreased. Marshland area decreased from 1,703.23 km² in the 1980s to 752.37 km² in 2015 (a 55.83% reduction), and the number of patches decreased

from 433 to 389. Aquaculture pond area increased from 1,423.83 km² in the 1980s to 2,934.59 km² in 2015 (a 106% increase), and the number of patches increased from 4,098 to 5,376, indicating that large areas of natural wetlands were converted to aquaculture ponds. Salt pan area decreased from 1,193.48 km² in the 1980s to 1,026.58 km² in 2015, and the number of patches decreased from 115 to 287, reflecting fragmentation of salt pans. Farmland area decreased from 56,061.14 km² to 51,683.58 km², and the number of patches decreased from 3,426 to 2,922.

Landscape changes can reflect alterations in landscape patterns to some extent. Analysis of habitat type changes since the 1980s shows that the mean patch area and aggregation index of marshland and salt pans have decreased. Mean patch area of marshland decreased from 3.93 km² in the 1980s to 1.93 km² (a 75.34% reduction), while mean patch area of salt pans decreased from 10.38 km² to 3.58 km². Mean patch area of lakeshore beaches and aquaculture ponds showed slight increasing trends. The aggregation index decreased from 55.82% to 35.91% for marshland and from 76.45% to 75.34% for salt pans, while the aggregation index for lakeshore beaches increased from 35.06% to 36.81%. Overall, the aggregation indices showed a decreasing trend.

All major wintering habitat types for red-crowned cranes showed decreasing areas and fragmentation, with marshland area loss being the most severe. The reduction in mean patch area and increasing fragmentation of habitat types are direct factors causing the loss of crane habitat distribution points. Habitat fragmentation caused by land-use pattern changes reduces habitat suitability for cranes, thereby affecting population size changes.

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3. Factors Influencing Red-crowned Crane Population and Habitat Changes

Changes in wintering crane population are closely related to habitat changes, and dynamic changes in habitat distribution inevitably affect crane survival and consequently population size. To identify driving factors influencing habitat changes, this study collected and compiled statistical yearbooks for Jiangsu Province for each year, selecting years corresponding to habitat distribution points. Factors reflecting socio-economic and land-use impacts were screened, including total population, gross regional product (×10), secondary industry gross product, housing construction area, and crop sowing area. SPSS 22.0 software was used to conduct correlation analysis between habitat distribution points and various influencing factors.

Correlation analysis results (Table 6) show that habitat distribution points are significantly negatively correlated with total population, gross regional product, secondary industry gross product, and housing construction area (R values of -0.866, -0.643, -0.655, and -0.614 respectively, all $p<0.01$), and significantly positively correlated with crop sowing area ($R=0.813$, $p<0.01$). The main reasons

are that population growth leads to increased human activity and disturbance, which is unfavorable for crane habitat selection and utilization. Gross regional product and secondary industry gross product represent economic development levels, indicating that rapid economic development adversely affects crane habitat changes. Housing construction area is significantly negatively correlated with habitat distribution points because increased building area encroaches upon and squeezes other land types, including wintering habitats. Increased crop sowing area has a positive effect on habitat distribution point changes because farmland is also a wintering habitat type for cranes.

These results demonstrate that changes in crane habitat distribution points are closely related to land-use patterns and human disturbance activities. The pattern changes in various crane habitat types indicate that reduced mean patch area and intensified fragmentation are direct factors causing habitat distribution point loss. Habitat area reduction and fragmentation affect habitat quality, thereby influencing crane wintering population size changes.

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3. Conclusions and Discussion

Through historical data tracking and analysis of land-use data from different periods, this study systematically examined changes in red-crowned crane wintering population size and habitat. The basic conclusions are as follows:

First, red-crowned crane wintering population size has changed significantly, showing an initial increase followed by a decreasing trend, with the peak occurring in the 1990s. The main reasons for this phenomenon include: (1) lack of unified large-scale survey data, with limited data in literature that cannot fully reflect actual crane distribution; (2) during the 1980s, cranes were not only widely distributed in northern Jiangsu but also in lake areas of Jiangxi and even Hubei provinces, which were not included in these statistics; (3) during this period, crane distribution was extensive but scattered, making comprehensive data collection difficult; and (4) research on crane populations and habitats in China only gained attention in the 1990s, when Yancheng Reserve began annual surveys, providing detailed information on wintering population sizes.

Second, the wintering habitat distribution range of red-crowned cranes has gradually narrowed. As a typical wetland bird, the crane uses various wetland types as wintering habitats, including river-lake beaches, marshes, and coastal tidal flats. During the 1980s, these habitats were characterized by large areas and high continuity, with cranes widely distributed across these regions. However, since the early 1990s, land-use changes have caused inland lakeshore beaches to gradually lose their habitat function, forcing crane wintering distribution ranges to shift toward coastal Sheyang County, Binhai County, and Dongtai County. With increasingly vigorous coastal development, the coastal tidal flat habitat range for cranes has further decreased and fragmented, forcing cranes to concentrate in the core area of Yancheng Reserve in Sheyang County. This finding

aligns with research by Li Haiping and Li Jing.

Third, red-crowned crane wintering habitat changes are closely related to human land-use patterns and socio-economic development. When economic development levels were low, with minimal gross regional product and housing construction area, natural environmental protection was relatively good. However, rapid economic development and expansion of construction and industrial land have severely squeezed original natural habitats. Enhanced human economic activities have caused various habitat types to suffer different degrees of fragmentation, affecting crane habitat suitability. Habitat dynamic changes have led to fluctuations in crane population size.

Comprehensive analysis reveals that changes in crane wintering habitats are inseparable from surrounding land-use patterns, intensity, and human disturbance. Habitat area loss and fragmentation are the main factors affecting wintering population size. Recent studies have found that human disturbance accounts for an increasingly large proportion of impacts on bird habitats, and increasing total population numbers have become important factors affecting crane habitat changes.

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Note: Figure translations are in progress. See original paper for figures.