Pakistan J. Zool., pp 1-8, 2026. DOI: https://dx.doi.org/10.17582/journal.pjz/20251021040936

The Influence of Habitat Factors on Habitat Preference of Cranes During the Wintering Periods in the DMZ Border Area, South Korea

Hyun-Su Hwang, Myeong Cheol Kim and Hyungsoo Seo*

Protected Area Research Team, National Institute of Ecology, 1210, Geumgang-Ro, Seocheon 33657, South Korea

Article Information
Received 21 October 2025
Revised 25 November 2025
Accepted 11 December 2025
Available online 27 April 2026
(early access)

Authors' Contribution
H-SH conceived the ideas, conducted data analysis, contributed to writing the original paper, reviewed, and edited the final draft. MCK reviewed, supported and edited the final draft and conceived project administration and funding acquisition. HS conceived project administration and funding acquisition.

Key words
Flagship species, Land cover, Red-Crowned Crane, White-Naped Crane, Wintering period

ABSTRACT

The demilitarized zone (DMZ) border area has been subject to strict regulations on human activity for over 70 years due to military security concerns. These restrictions on human presence have allowed the area to develop diverse habitats with high biodiversity value. The red-crowned crane and white-naped crane, both endangered species and designated natural monuments, use the DMZ border area during their wintering periods and require protection. Effective management and conservation efforts for these species demand detailed information, including species-specific habitat use based on habitat characteristics. Therefore, we investigated the influence of land cover characteristics on these two crane species during their wintering periods in the DMZ border area by classifying land cover using Landsat 8 satellite imagery. The areas of the core and buffer zones during the early and middle wintering periods did not differ. The densities of red-crowned and white-naped cranes were influenced by the composition of agricultural areas, wetlands, and water bodies. These land cover types are associated with food availability for both species during winter. Consequently, conservation and protection efforts for these cranes in the DMZ border area during the wintering period should focus on minimizing habitat alteration and managing agricultural areas, wetlands, and water bodies to ensure a stable supply of food resources.

INTRODUCTION

On the Korean Peninsula, the demilitarized zone (DMZ), established as a result of the Korean War from 1950 to 1953, extends 2 km from the Military Demarcation Line, while the Civilian Control Zone (CCZ) extends 10 km from the line. Both zones impose significant restrictions on human activity. The DMZ border area, which includes both the DMZ and the CCZ, has maintained limited human interference for nearly 70 years, resulting in exceptionally high species diversity. According to an ecological survey conducted by the National Institute of Ecology in 2020, the CCZ is home to 1,126 species of vascular plants, 24 species of mammals, 145 species of birds, 29 species of amphibians and reptiles, 2,283 species of insects, 334 species of benthic macroinvertebrates, 81 species of fish, and 293 species of spiders. In total, 4,315 species representing 16.5% of all species found in South Korea were identified, including 44 endangered species. The DMZ border area encompasses a variety of habitats characterized by diverse topography and land cover patterns (Grichting and Kim, 2013). The eastern side features high elevations, steep slopes, and predominantly forested habitats, with small patches of grassland, watersheds, and barren areas scattered throughout. In contrast, the western side of the DMZ border area has lower elevations, gentler slopes, and land cover dominated by grasslands and watersheds. The diversity of habitat types is closely linked to biodiversity, as different species have varying habitat preferences (Sergio *et al*., 2004).

DMZ border area faces developmental pressure despite its high conservation value. In particular, the western side of the DMZ border is adjacent to large metropolitan areas in both South and North Korea. Increased human activity in this region can lead to a decline in biodiversity. To support various conservation efforts aimed at protecting habitats and biodiversity, which require significant ecological and economic resources, one effective approach is to identify and protect flagship species (Jepson and Barua, 2013; Mcgowan *et al*., 2020). This method demands relatively low economic and ecological costs. Therefore, the red-crowned crane

* Corresponding author: pinus@nie.re.kr
0030-9923/2026/0001-0001 $ 9.00/0

(*Grus japonensis*) and the white-naped crane (*Antigone vipio*) have been designated as flagship species for the DMZ border area to help preserve its biodiversity. These species are classified as endangered species I and II, respectively, by the Ministry of Environment and are recognized as natural monuments by the Korea Heritage Service.

Developing a conservation plan for target species requires a thorough understanding of their habitat characteristics and usage patterns (Lahoz-Monfort and Magrath, 2021; Roy *et al*., 2022). However, studies on the habitat preferences of the red-crowned crane and white-naped crane, particularly in the DMZ border area, remain insufficient. The unique characteristics of the DMZ, including restrictions on human activity, necessitate careful assessment of habitat variables and species surveys conducted uniformly by researchers. Therefore, our study focuses on the habitat use of red-crowned and white-naped cranes during their wintering period, providing detailed ecological insights into their habitat preferences within the DMZ border area.

MATERIALS AND METHODS

Study area

This study was conducted from December 2021 to January 2025 in the western side of the DMZ border area, including Paju-si, Yeoncheon-gun, and Cheolwon-gun. This region covers approximately 836.21 km², with elevations ranging from 0 m to 1,171 m. The eastern area, Cheolwon-gun, has a high elevation, while the western area, Paju-si, has a much lower elevation. Additionally, this area contains five types of protected zones, covering approximately 147.85 km², designated by the Ministry of Environment, Korea Forest Service, and Korea Heritage Service (Fig. 1).

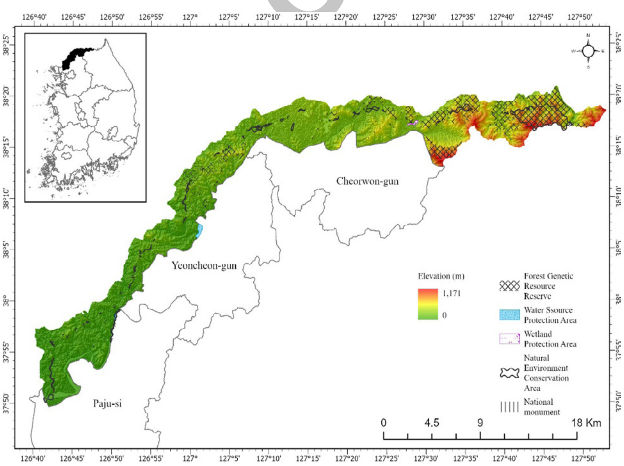

Fig. 1. Location of study area in DMZ border area at Paju-si, Yeoncheon-gun, and Cheolwon-gun, South Korea.

Data collection

We used data collected from the ecological survey of flagship species cranes along the DMZ border area, including coordinate information and individual counts, to assess habitat use patterns of 2 crane species. These surveys were conducted annually in December, representing the early wintering season, and in January, representing the mid-wintering season, to analyze population dynamics between these periods. Each field survey lasted five days, with careful consideration of weather conditions and military security.

Analysis of data

After the field survey, we calculated the density, core area, and buffer area of the red-crowned crane and white-naped crane at each survey site. To estimate the core and buffer areas, we conducted kernel density estimation (KDE) and minimum convex polygon (MCP) analyses. We then calculated the 90% and 50% KDE and MCP contours to define the buffer and core areas, respectively. These calculations were performed using R (ver. 4.4.1) with the adehabitatHR package (Calenge, 2011).

The study then examines the effect of land cover composition on habitat selection by the red-crowned crane and white-naped crane by classifying the characteristics of habitat patches within the study area. Habitat patches were categorized into 7 cover types: urban, agriculture, forest, grassland, barren land, wetland, and waterbody. For patch classification, we employed remote sensing techniques using Landsat 8 satellite imagery with a spatial resolution of 30 m, covering the period from 2021 to 2025, with a particular focus on the winter season. An unsupervised classification method based on maximum likelihood was applied to generate multiple spectral signatures (Osman *et al*., 2022). Following land cover classification, we assessed classification accuracy using a confusion matrix and Cohen's kappa coefficient, referencing Google Map (Rwanga and Ndambuki, 2017). All land cover classification procedures were conducted using ArcGIS Pro (Esri, USA). The analysis of Cohen's kappa coefficient and the confusion matrix was performed using ArcGIS Pro (Esri, USA) and R (ver. 4.4.1) with the CARET package (Kuhn, 2008). Additionally, to assess the effect of human disturbance on the density of both crane species, we calculated the total length of road edges per square kilometer in our study area using high-resolution Google Maps to quantify human disturbance.

Statistical analysis

To evaluate the effect of land coverage on the density of red-crwoned crane and white-naped crane, we conducted statistical analyses using R (ver. 4.4.1). We performed a Mann-Whitney U test to assess differences in characteristics of patch and density of 2 cranes on each wintering pattern. Additionally, to address potential multicollinearity issues in the models, we calculated variance inflation factors (VIF) for each predictor variable. All VIF values were below 2, indicating no significant multicollinearity. We employed a Generalized Linear Model (GLM) to model the density of both red-crwoned crane and white-naped crane in relation to land coverage. After model selection based on AIC (ΔAIC < 2), we calculated averaged regression coefficients and assessed the relative importance of variables using the MuMIn R package (Bartoń, 2022).

RESULTS

The results of remote sensing analysis for land cover classification using Landsat 8 satellite images from November 2021 to January 2025 in our study area showed an accuracy ranging from 84.76% to 86.34%, with a kappa coefficient between 0.76 and 0.78. The error rate ranged from 13.66% to 15.24% (Table I). Based on the classification of land cover from the Landsat 8 images, there were no significant differences in land cover within the DMZ, CCZ, and DMZ border areas during the period from November 2021 to January 2025 (Table II, Fig. 2).

Table I. Result of confusion matrix of classification land cover on DMZ border region during November 2021 to February 2025 in South Korea.

Season	Accuracy (%)	Error rate (%)	p	Kappa coefficient
Nov. 2021 to Feb. 2022	86.22	13.78	<0.001	0.78
Nov. 2022 to Feb. 2023	85.34	14.66	<0.001	0.76
Nov. 2023 to Feb. 2024	86.34	13.66	<0.001	0.78
Nov. 2024 to Feb. 2025	84.76	15.24	<0.001	0.76

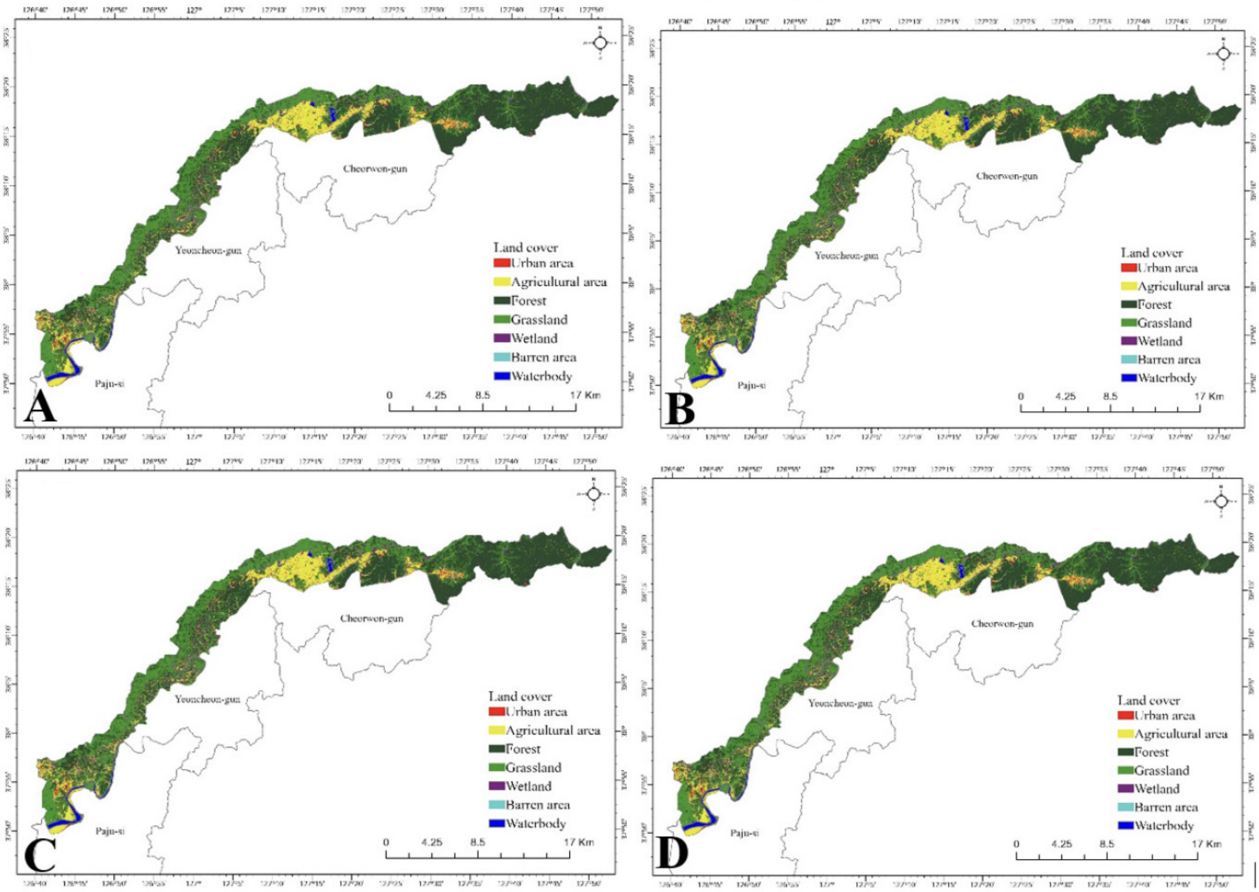

Fig. 2. Land cover on the DMZ border area resulted by unsupervised classification method during November 2021 to February 2025 (A): November 2021 to February 2022, (B) November 2022 to February 2023, (C): November 2023 to February 2024, (D): November 2024 to February 2025.

Table II. Proportion of land coverage (mean±S.E.) on the DMZ, CCZ, and DMZ border area during November 2021 to February 2025 resulted by unsupervised classification method.

Area	URB	AGR	FOR	GRA	WET	BAR	WAT	F	p
DMZ	0.49±0.00	2.19±0.00	38.87±0.00	52.36±0.00	4.74±0.00	0.13±0.00	1.21±000	0.43	0.52
CCZ	3.36±0.00	16.43±0.16	45.43±0.03	23.46±0.02	8.10±0.00	0.55±0.01	2.67±0.13	3.46	0.07
Border	2.38±0.00	11.25±0.00	43.25±0.00	33.38±0.00	6.97±0.00	0.39±0.00	2.43±0.00	1.92	0.18

URB, urban area; AGR, agricultural area; FOR, forest; GRA, grassland; WET, wetland; BAR, barren area; WAT, waterbody; Border, DMZ border area.

Table III. Difference of characteristics on habitat usage (mean±S.E.) between early and middle periods on red-crowned crane (*Grus japonensis*) and white-naped crane (*Antigone vipio*).

Species		Early	Middle	Z	p
G. japonensis	**Area (km^2)**				
	KDE_Core	410.39±69.91	413.80±67.95	-0.03	0.97
	KDE_Buffer	1,710.87±368.45	1,579.49±320.93	-0.26	0.80
	MCP_Core	195.70±53.67	198.10±62.04	-0.03	0.98
	MCP_Buffer	802.47±236.90	267.98±205.35	-0.32	0.75
	Density (individual/km^2)				
	KDE_Core	3.91±1.04	3.95±1.06	-0.03	0.98
	KDE_Buffer	1.59±0.28	1.52±0.34	-0.14	0.89
	MCP_Core	3.98±0.89	3.79±1.08	-0.13	0.90
	MCP_Buffer	2.13±034	2.23±0.44	-0.18	0.86
A. vipio	**Area (km^2)**				
	KDE_Core	259.06±60.21	284.51±67.32	-0.27	0.79
	KDE_Buffer	1,323.81±358.20	1,385.70±364.38	-0.12	0.91
	MCP_Core	169.04±45.82	252.69±91.95	-0.76	0.45
	MCP_Buffer	1,032.40±319.37	996.69±301.48	-0.08	0.94
	Density (individual/km^2)				
	KDE_Core	30.38±9.95	20.50±4.69	-0.84	0.40
	KDE_Buffer	9.19±2.35	7.26±1.33	-0.67	0.50
	MCP_Core	22.66±5.96	13.06±2.58	-1.31	0.19
	MCP_Buffer	8.69±1.30	8.16±0.36	-0.37	0.71

Estimating for home range size by KDE and MCP, the size of core and buffer area between early and middle seasons of wintering periods, red-crowned crane and white-naped crane were not differed significantly. Moreover, early and middle periods of wintering, population density of red-crowned crane and white-naped crane on core and buffer area, calculated by KDE and MCP was not differed significantly (Table III).

Eight habitat variables, including the proportion of land cover types and road density, differed between the core and buffer areas for both the red-crowned crane and the white-naped crane. For the red-crowned crane, the proportions of urban area, forest, grassland, and wetland were higher in the buffer area, whereas the proportions of agricultural area and road density were higher in the core area (Table IV). Similarly, for the white-naped crane, the proportions of urban area, grassland, and wetland were higher in the buffer area, while agricultural and barren areas were more prevalent in the core area. Road density and the proportion of forest did not differ significantly between the core and buffer areas for the white-naped crane (Table IV). The proportion of waterbody did not differ between core and buffer areas for either species.

The top-ranked model for the density of the red-crowned crane was 0.16 × agricultural area + 0.20 × wetland + 2.59 × waterbody + 0.73 × road density (χ2-test, $p < 0.01$). Similarly, the top-ranked model on the density of white-naped crane was 0.27× agricultural area + 3.27× wetland

+ 5.29× road density (χ2-test, $p < 0.01$) (Table V). For the red-crowned crane, the proportion of agricultural area was the most important variable positively associated with its density. Road density was the second most important variable influencing red-crowned crane density. The proportions of wetland and waterbody were less important variables for red-crowned crane density. Similarly, for the white-naped crane, the proportion of agricultural area was the most important variable, followed by road density as the second most important variable. Waterbody proportion was less important for the density of the white-naped crane (Table VI).

Table IV. Differences of proportion of land coverage (mean±S.E.) between core area and buffer area on red-crowned crane and white-naped crane.

Variables	Core area	Buffer area	Z	p
Red-crowned crane				
Urban	3.51±0.10	3.87±0.06	-2.61	0.01
Agriculture	60.91±1.84	19.71±1.94	-6.27	<0.01
Forest	5.68±0.91	26.48±1.07	-6.18	<0.01
Grassland	14.85±0.80	34.55±1.05	-6.20	<0.01
Wetland	11.08±0.43	12.33±0.19	-2.36	0.02
Barren area	0.93±0.06	0.58±0.03	-3.82	<0.01
Waterbody	3.04±0.34	2.47±0.08	-1.50	0.13
Road density (km/km^2)	9.97±0.34	6.67±0.12	-5.15	<0.01
White-naped crane				
Urban	2.94±1.44	4.37±1.25	-4.15	<0.01
Agriculture	61.07±6.33	42.42±3.65	-2.27	0.02
Forest	9.14±2.60	14.64±1.67	-1.66	0.10
Grassland	13.29±2.63	22.31±1.86	-2.45	0.01
Wetland	9.82±0.96	12.43±0.43	-2.22	0.03
Barren area	1.06±0.05	0.88±0.04	-2.47	0.01
Waterbody	2.68±0.53	2.96±0.14	-0.50	0.62
Road density (km/ km^2)	10.97±0.98	9.82±1.29	-0.69	0.49

Table V. Models based on the correlated Akaike Information Criterion (AICc) developed to explain the density of red-crowned crane (*Grus japonensis*) and white-naped crane (*Antigone vipio*) in each landscape indices ranked by the ΔAICc value resulted by the generalized linear model.

Species	Model	AIC_c	ΔAIC_c	ω	R^2
G. japonensis	(Intercept + agriculture + wetland + waterbody + road density)	80.01	0.00	1.00	0.93
A. vipio	(Intercept + agriculture + wetland + road density)	185.92	0.00	0.86	0.55

Table VI. Coefficients and relative variable importance, including the best model that explains the variability in the density of landscape indices for each species.

Variables	Coefficient	S.E.	Z	P	Relative variable importance
***Grus japonensis* (red-crowned crane)**					
Intercept	-0.76	0.32	-0.61	0.55	
Agriculture	0.16	0.14	1.20	0.26	100.00
Wetland	0.20	0.89	0.23	0.83	8.79
Waterbody	2.59	0.91	2.84	0.02	0.00
Road density	0.73	1.90	0.39	0.71	85.60
***Antigone vipio* (white-naped crane)**					
Intercept	-2.56	0.94	-2.73	0.02	
Agriculture	0.27	1.00	0.27	0.79	100.00
Wetland	3.27	1.10	2.96	0.01	0.00
Road density	5.29	4.75	1.11	0.29	28.14

DISCUSSION

Habitat land cover, one of the most useful factors for assessing changes in patch types within habitats, influences habitat selection for foraging and roosting sites based on species-specific behavioral characteristics (Sutherland and Green, 2004; Lumbierres *et al*., 2022). Classifying habitat patches is challenging due to the difficulty in accurately assessing the shape and boundaries of each patch. Remote sensing techniques are valuable for estimating habitat characteristics, including land cover (McDermid *et al*., 2009), burn severity (Barmpoutis *et al*., 2020), habitat heterogeneity (Georganos *et al*., 2021), and habitat suitability (Cisneros-Araujo *et al*., 2021). Our study area, the DMZ border area, restricts human access and activity due to military security, which also limits researchers' ability to obtain information for calculating habitat characteristics. Therefore, using remote sensing techniques with satellite imagery is helpful for estimating habitat characteristics in this area. Moreover, our data indicate that land cover in the study area from December 2021 to January 2025 remained unchanged. Changes in the composition and characteristics of patches can lead to disturbances in populations, while more stable habitats can promote population stability (Cuarón, 2000; Wu *et al*., 2022). Despite the short temporal period, the stable composition of land cover may suggest that limited human activity in the study area provides a stable environment for wildlife.

The quality and quantity of food resources within a habitat are among the most important factors influencing species habitat preferences (Cuttriss *et al*., 2015; Schlacher *et al*., 2014). In particular, during the wintering period in temperate zones, low temperatures and limited food availability pose significant challenges to individual survival and the maintenance of homeostasis (Hwang *et al*., 2025). Red-crowned cranes and white-naped cranes primarily consume grain-based food resources during their wintering period in South Korea (Min and Choi, 2022). Consequently, agricultural areas with paddy fields serve as important foraging sites for these cranes. Additionally, wetlands and water bodies influence the populations of red-crowned and white-naped cranes by providing essential resting sites of adequate quality and quantity (Zhang *et al*., 2015; Zou *et al*., 2021). Both crane species select wetlands and the edges of water bodies for resting and foraging. Therefore, the composition of wetlands and water bodies within their habitat significantly affects these cranes. In our study, results from a generalized linear model indicated that wetlands and water bodies positively influenced the populations of red-crowned and white-naped cranes. Generally, urban areas, including roads, negatively impact wildlife by causing habitat loss and increasing mortality due to accidents (von Der Lippe *et al*., 2020; Reis *et al*., 2012). However, our results showed that road density positively influenced the density of red-crowned and white-naped cranes, while the proportion of urban area had no significant effect on their density. In our study area, particularly the CCZ, agricultural activities continue until late fall, and roads are often adjacent to agricultural areas with high density. During winter, after the harvest season, traffic decreases as agricultural activities cease. Furthermore, as winter progresses, cranes become less sensitive to human activity due to the decreasing availability of food resources (Wu *et al*., 2020). These findings support the conclusion that the composition of habitat patches specifically agricultural areas, wetlands, and water bodies is crucial for providing foraging and resting sites for these two crane species during the wintering period.

Despite the limitations in collecting field survey and habitat variable data for our study, our results indicate that agricultural areas and patches associated with water, wetlands, and water bodies are primarily important habitat types for red-crowned cranes and white-naped cranes during the wintering period. Although changes in land cover within the CCZ during the study period were not significant at the 95% confidence interval, they were significant at the 90% confidence interval. The CCZ, which is subject to less regulation of human activity than the DMZ, experiences relatively high disturbance pressure due to a high proportion of agricultural land an important variable positively correlated with the density of both crane species. Therefore, conservation efforts for red-crowned and white-naped cranes in the DMZ border area should focus more on managing agricultural areas, wetlands, and water bodies.

DECLARATION

Acknowledgments

We appreciate Dr. Lee Ki-Sup, Mr. Shin Ju-Yeol, and Dr. Park Jong-Hyun for supporting the field survey.

Funding

This work was supported by the National Institute of Ecology, South Korea under Grant [NIE-C-2025-06-01].

Generative AI and AI-assisted technology statement

The authors declare that no generative AI and AI assisted technology was used in the creation of this manuscript.

Statement of conflict of interest

The authors have declared no conflict of interest.

REFERENCES

Barmpoutis, P., Papaioannou, P., Dimitropoulos, K. and Grammalidis, N., 2020. A review on early forest fire detection systems using optical remote sensing. *Sensors*, **20**: 6442. https://doi.org/10.3390/s20226442

Bartoń, K., 2022. *MuMIn: Multi-model inference*. R package version 1.46. 0.

Calenge, C., 2011. *Home range estimation in R: The adehabitatHR package*. Office national de la classe et de la faune sauvage: Saint Benoist, Auffargis, France.

Cisneros-Araujo, P., Goicolea, T., Mateo-Sanchez, M.C., Garcia-Vinas, J.I., Marchamalo, M., Mercier, A. and Gaston, A., 2021. The role of remote sensing data in habitat suitability and connectivity modeling: insights from the cantabrian brown bear. *Remote Sens*., **13**: 1138. https://doi.org/10.3390/rs13061138

Cuarón, A.D., 2000. Effects of land-cover changes on mammals in a neotropical region: a modeling approach. *Conserv. Biol*., **14**: 1676-1692. https://doi.org/10.1111/j.1523-1739.2000.99211.x

Cuttriss, A., Maguire, G.S., Ehmke, G. and Weston, M.A., 2015. Breeding habitat selection in an obligate beach bird: a test of the food resource hypothesis. *Mar. Freshw. Res*., **66**: 841-846. https://

doi.org/10.1071/MF14213

Georganos, S., Grippa, T., Niang Gadiaga, A., Linard, C., Lennert, M., Vanhuysse, S., Mboga, N., Wolff, E. and Kalogirou, S., 2021. Geographical random forests: a spatial extension of the random forest algorithm to address spatial heterogeneity in remote sensing and population modelling. *Geocart. Int*., **36**: 121-136. https://doi.org/10.1080/10106049.2019.1595177

Grichting, A. and Kim, K.G., 2013. The Korea DMZ: From a red zone to a deeper shade of green. In: *Greening in the red zone: Disaster, resilience and community greening*. Dordrecht: Springer Netherlands. pp. 197-201. https://doi.org/10.1007/978-90-481-9947-1_15

Hwang, H., Lee, J., Eom, T., Lee, D. and Rhim, S., 2025. Short-term effects of winter food supply on the breeding performance of the great tit (*Parus major*). *Pakistan J. Zool*., **57**: 1453-1456. https://doi.org/10.17582/journal.pjz/20230725081750

Jepson, P. and Maan, B., 2013. A theory of flagship species action. *Conserv. Soc*., **13**: 95-104. https://doi.org/10.4103/0972-4923.161228

Kuhn, M., 2008. Caret package. *J. Stat. Softw*., **28**: 1-26. https://doi.org/10.18637/jss.v028.i05

Lahoz-Monfort, J.J. and Magrath, M.J., 2021. A comprehensive overview of technologies for species and habitat monitoring and conservation. *Bioscience*, **71**: 1038-1062. https://doi.org/10.1093/biosci/biab073

Lumbierres, M., Dahal, P.R., Di Marco, M., Butchart, S.H., Donald, P.F. and Rondinini, C., 2022. Translating habitat class to land cover to map area of habitat of terrestrial vertebrates. *Conserv. Biol*., **36**: e13851. https://doi.org/10.1111/cobi.13851

McDermid, G.J., Hall, R.J., Sanchez-Azofeifa, G.A., Franklin, S.E., Stenhouse, G.B., Kobliuk, T. and LeDrew, E.F., 2009. Remote sensing and forest inventory for wildlife habitat assessment. *For. Ecol. Manage*., **257**: 2262-2269. https://doi.org/10.1016/j.foreco.2009.03.005

McGowan, J., Beaumont, L.J., Smith, R.J., Chauvenet, A.L.M., Harcourt, R., Atkinson, S.C., Mittermeier, J. C., Esperon-Rodriguez, M., Baumgartner, J.B., Beattie, A., Dudaniec, R.Y., Grenyer, R., Nipperess, D.A., Stow, A. and Possingham, H.O., 2020. Conservation prioritization can resolve the flagship species conundrum. *Nat. Commun*., **11**: 994. https://doi.org/10.1038/s41467-020-14554-z

Min, K. and Choi, M.A., 2022. Resource landscape, microbial activity, and community composition under wintering crane activities in the Demilitarized Zone, South Korea. *PLoS One*, **17**: e0268461 https://doi.org/10.1371/journal.pone.0268461.

National Institute of Ecology, 2020. *The ecological survey on the Korean Demilitarized Zone (DMZ) and its surrounding areas*. (In Korean).

Osman, A., Mariwah, S., Yawson, D.O. and Atampugre, G., 2022. Changing land cover and small mammal habitats: Implications for landscape ecological integrity. *Environ. Chall*., **7**: 100514. https://doi.org/10.1016/j.envc.2022.100514

Reis, E., López-Iborra, G.M. and Pinheiro, R.T., 2012. Changes in bird species richness through different levels of urbanization: Implications for biodiversity conservation and garden design in Central Brazil. *Landsc. Urban Plann*., **107**: 31-42. https://doi.org/10.1016/j.landurbplan.2012.04.009

Roy, S., Suman, A., Ray, S. and Saikia, S.K., 2022. Use of species distribution models to study habitat suitability for sustainable management and conservation in the Indian subcontinent: A decade's retrospective. *Front. Sustain. Resour. Manage*., 1: 1031646. https://doi.org/10.3389/fsrma.2022.1031646

Rwanga, S.S., Ndambuki, J.M., 2017. Accuracy assessment of land use/land cover classification using remote sensing and GIS. *Int. J. Geo. Geosci*., **8**: 611. https://doi.org/10.4236/ijg.2017.84033

Schlacher, T.A., Meager, J.J. and Nielsen, T., 2014. Habitat selection in birds feeding on ocean shores: landscape effects are important in the choice of foraging sites by oystercatchers. *Mar. Ecol*., **35**: 67-76. https://doi.org/10.1111/maec.12055

Sergio, F., Marchesi, L. and Pedrini, P., 2004. Integrating individual habitat choices and regional distribution of a biodiversity indicator and top predator. *J. Biogeogr*., **31**: 619-628. https://doi.org/10.1046/j.1365-2699.2003.01002.x

Sutherland, W.J. and Green, R.E., 2004. *Habitat assessment. Bird ecology and conservation*. Oxford University Press, Oxford. pp. 251-268. https://doi.org/10.1093/acprof:oso/9780198520863.003.0011

von Der Lippe, M., Buchholz, S., Hiller, A., Seitz, B. and Kowarik, I., 2020. CityScapeLab Berlin: A research platform for untangling urbanization effects on biodiversity. *Sustainability*, **12**: 2565. https://doi.org/10.3390/su12062565

Wu, D., Hu, C., Zhang, M., Li, Z., Su, H., 2020. Foraging habitat selection of overwintering black-necked cranes in the farming area surrounding the Caohai Wetland, Guizhou Province, China. *Avian Res*., **11**: 5. https://doi.org/10.1186/s40657-020-00192-y

Wu, J., Luo, J., Zhang, H., Qin, S. and Yu, M.,

2022. Projections of land use change and habitat quality assessment by coupling climate change and development patterns. *Sci. Total Environ*., **847**: 157491. https://doi.org/10.1016/j.scitotenv.2022.157491

Zhang, D., Zhou, L. and Song, Y., 2015. Effect of water level fluctuations on temporal-spatial patterns of foraging activities by the wintering Hooded Crane (*Grus monacha*). *Avian Res*., **6**: 16. https://doi.org/10.1186/s40657-015-0026-x

Zou, L., Hu, B., Qi, S., Zhang, Q. and Ning, P. 2021. Spatiotemporal variation of Siberian crane habitats and the response to water level in Poyang Lake Wetland, China. *Remote Sens*., **13**: 140. https://doi.org/10.3390/rs13010140