

Research Paper

Simulation of crane habitat fragmentation in the North and South Korean border region after Korean reunification



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HIGHLIGHTS

- Crane habitat in the North and South Korean border had been over the last decades.
- Korean reunification will accelerate crane habitat fragmentation in the border region.
- Linear road constructions will be particularly effective in crane habitat fragmentation.
- A clustered development can minimize habitat fragmentation after reunification.

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ABSTRACT

The North and South Korean border region where human access has been restricted for the last six decades has served as one of the last wintering habitats for two endangered crane species [red-crowned crane (*Grus japonensis*) and white-naped crane (*Grus vipio*)], but this valuable habitat is expected to be threatened once humans can freely access after Korean reunification. This study examined how the crane habitat in the Korean border region will be degraded by land cover change after Korean reunification. The crane habitat was identified using land cover maps derived from Landsat Thematic Mapper images. Post-reunification crane habitat was simulated based on three land cover change scenarios that are likely to occur in this region. Four landscape metrics, including total and core crane habitat areas, were calculated to assess habitat fragmentation under the three land cover change scenarios. The results show that the core crane habitat area decreased by 544.6 km² (44.3% of crane habitat in the late 1980s) over the last two decades and will further decrease after Korean reunification. It was predicted that, even if the border region will be protected as a DMZ national park, only a few new road constructions that will be inevitable to reconnect the two sides of Korea will destroy 47.3 km² of core crane habitat, which is more than three times greater than the loss of total crane habitat of 14.7 km². It is needed to prepare a land use plan that can minimize the crane habitat fragmentation after Korean reunification.

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1. Introduction

Since the Korean War in the 1950s, the North and South Korean border region has been heavily armed, and human access to this region has been strictly restricted. Under the armistice agreement that ended the war in 1953, the 4-km wide demilitarized zone (DMZ) was established by retreating each side by 2 km from the military demarcation line. Fences and guard posts were installed along the both sides of the DMZ boundary, and military and civilian accesses have been prohibited. Only a few human activities have

occurred within the DMZ. The Panmunjom village inside the North Korean side of the DMZ is a joint security area where peace discussions between North and South Korea have been held. Around the Panmunjom village are small propagation villages built by either side. Violating the armistice agreement, both sides operate many military guard posts within the DMZ. In addition, South Korea established the civilian control zone (CCZ) within the 1–12 km wide region to the south from the DMZ and allows only farmers and tourists with special permits to enter this zone (John, Youn, & Shin, 2003). Besides these legal restrictions, numerous lost landmines keep people away from this region (Yoo, Lee, & Park, 2012). As a result of this human access restriction, the border region remains intact and ironically becomes a refuge for many endangered wildlife species (Kim & Cho, 2005). A recent study reported that there were 1597 plant, 2312 insect, 100 fish, 98 bird, and 11

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mammal species in the study area (Korea Forest Research Institute & Ministry of Environment 2004).

Of the many endangered wildlife species, a red-crowned crane (*Grus japonensis*) is perhaps the most renowned one because they are internationally threatened and culturally significant to local people. Cranes are a symbol of longevity and good luck in many East Asian cultures (Kim, Steiner, & Mueller, 2011). They are migratory birds that breed in northeastern China, eastern Russia, and Mongolia and winter in Yancheng in southern China, southern Japan, and the North and South Korean border. The border region is also an important stopover site where cranes rest and refuel during migration (Higuchi et al., 1996, 1998). A white-naped crane (*Grus vipio*) is another endangered crane species that shares habitat in the border region with a red-crowned crane. Both species are classified as the International Union for Conservation of Nature (IUCN) red list of threatened species (IUCN, 2013). The border region is one of the last wintering habitats for both species. A mosaic of coastal and riparian marshes, rice paddies, and open grasslands provide wintering habitat for the two species. About 1000 red-crowned cranes and 1900 white-naped cranes winter in this region from mid-October to early March (Lee, Kim, & Koo, 2009; Yoo, Kwon, Park, & Park, 2011).

Turning to the 1990s, there were many construction projects as a consequence of North and South Korean economic cooperation and suburban expansion of the Seoul metropolitan area (Sung & Cho, 2012). As one of the first outcomes of the economic cooperation, the Kaesong industrial park, a 66 km² industrial complex, was constructed and operated by the South Korean private companies since 2003. The Paju new town, a suburban town of the Seoul Metropolitan area, is another major construction project that was developed in 17 km² for 200,000 residents. Many other land developments by private parties also occurred during the last decades.

The recent land developments resulted not only in the loss of wildlife habitats, but also the fragmentation of the remnant habitats in this region (Sung & Cho, 2012). Habitat fragmentation has an adverse impact on wildlife conservation because it weakens the connectivity between habitat patches and increases the area of edge habitat that is influenced by the adverse effect from the surroundings (Black, Carbone, Wells, & Owen, 1992; Proctor, Broom, & Ruxton, 2006; Viña et al., 2007). Like other bird species, cranes are also susceptible to this so-called edge effect because they are exposed to higher risk of predation in the edge habitats, which makes them spend more time and energy to defense (Wang, Li, Beauchamp, & Jiang, 2011; Yoo, Lee, & Yoo, 2007).

The loss and fragmentation of crane habitat in this region is expected to continue on once North and South Korea are reunified. The relationship between North and South Korea is still very hostile, but two Koreas will eventually be reunified sometime in the future. Some people claim that this region should be developed to expedite the economic growth of North Korea (Jo, Kim, Park, Choi, & Hwang, 2012). Fortunately, however, there is a general consensus on the idea that the border region should be designated as a DMZ national park and reserved for cranes and other wildlife species (Choi & Park, 2009; Kim, 1997). Local farmers still disagree with the idea of the national park owing to their concern of their property rights being limited by the park regulation, but their attitudes on crane conservation become more positive as they recognize that people pay more for their agricultural products grown in a clean environment where cranes can live (Kim et al., 2011).

In preparation for Korean reunification, this paper examined how crane habitat in the border region will change by post-reunification land cover change. Scenario-based wildlife habitat simulation has been widely conducted in previous studies that projected the changes in wildlife habitat in different socio-environmental conditions. Some studies assessed the effect of future urban and suburban development on local biodiversity

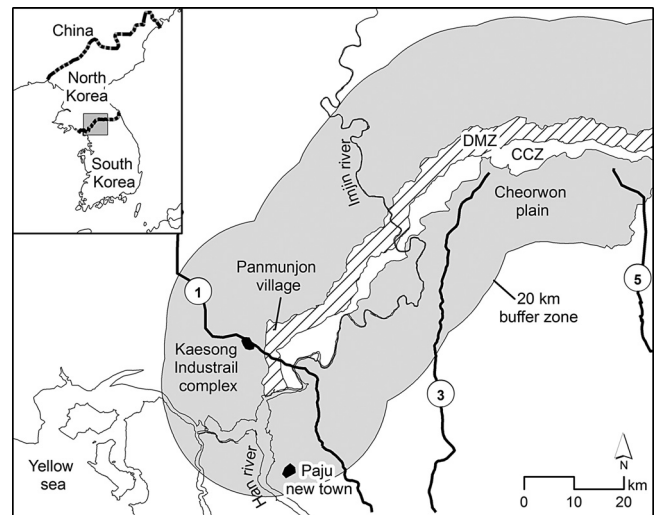


Fig. 1. Map of the study area.

(Gude, Hansen, & Jones, 2007; Swenson & Franklin, 2000), while others focused on habitat changes for specific species, such as mammals (Schumaker, Ernst, White, Baker, & Haggerty, 2004), birds (Schleupner & Link, 2008; Schumaker et al., 2004), reptiles and amphibians (Bolliger, Kienast, Soliva, & Rutherford, 2007; Rustigian, Santelmann, & Schumaker, 2003), insects (Bolliger et al., 2007), and fish (van Sickle et al., 2004) in rural landscapes. In general, those previous studies examined species that were sensitive to adjacent human land uses. Cranes are also sensitive to human interruption, but cranes in the Korean border region adapt to human interruption in the sense that they heavily rely their foods on rice grains fallen in croplands (Lee, Jabłoński, & Higuchi, 2007). Hence, it is expected that the effect of post-reunification land cover change on crane habitat fragmentation will be much more complex than those in the previous studies. Three land cover change scenarios that will be likely to occur after Korean reunification were generated, and four landscape metrics, including total and core crane habitat areas, were calculated to examine the effect of post-reunification land cover change on crane habitat fragmentation. Based on the results, several policy implications on crane conservation were discussed.

2. Materials and methods

2.1. Study area

The study area is the western half of the North and South Korean border region including the DMZ and its 20 km buffer zone (Fig. 1). The eastern half of the border region was excluded since it is a forested mountain region that is not suitable for crane habitat. The study area consists of the 4-km wide DMZ, the 1–12 km wide CCZ in the South Korean side, and the non-military zones in the North and South Korean sides. The study area has complex landscape with the Han River estuary in the west and the Cheorwon Plain in the east. The Han and Imjin Rivers flow through the study area from east to west, creating narrow floodplains surrounded by hilly mixed forests that have regrown after the Korean War. Historically, a large portion of the riparian floodplains had been used as croplands, mainly rice paddies, but many of them in the DMZ were derelict and back to the natural wetlands (Lee, Rhim, & Park, 2001; Lee et al., 2009). Large patches of grassland were formed by natural floods and sporadic brush burnings set by either side of the military to clear the sight of the guards.

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