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Status and ecological resource value of the Republic of Korea's De-militarized Zone

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Abstract This paper explores the status and value of ecological resources found in the De-militarized Zone (DMZ), an area of land separating North and South Korea, in terms of habitats and species. This approach contrasts with a conventional species-driven approach. There have been few surveys of ecological resources in the DMZ due to land mines and security issues. As such, there appear to be a number of less well known habitats and understudied and data deficient species within the DMZ. This paper seeks to improve knowledge of ecological resources within the DMZ by combining and synthesizing the author's study results with the outcome of surveys of the DMZ conducted by various organizations. The paper also includes ecological mapping results. Conservation value is assessed using priorities identified by a number of Korean and foreign institutions. The conservation value of habitats, particularly of wetlands including peatland, is based on the Ramsar Site criteria, the International Peat Society criteria, and the designation criteria for the UNESCO World Natural Heritage and Biosphere Reserve. As in-depth studies on the functions of DMZ habitats are not available due to the constraints mentioned above, the habitat assessment is inevitably tentative. Species value is based on the IUCN's Red Data Book (1997). This paper seeks to be used as material contributing to the conservation and sustainable use of the DMZ. In particular, this paper aims to aid in the designation of the DMZ as a World Natural Heritage site through the identification and suggestion of key or prime biodiversity areas within the DMZ. This is completed by using a model suggested by English Nature (UK) based on the aforementioned criteria.

Keywords Conservation value assessment · Ramsar Site · Wetlands · World Natural Heritage · Biosphere reserve

Introduction

The De-militarized Zone (DMZ) in the Republic of Korea (ROK) acts as both a tragic symbol of the confrontation and division between South and North Korea as well as a global treasure house of ecosystems. The place, a heart-breaking and tragic site to Koreans, is the largest piece of land on earth divided for political reasons. Accordingly, the area has been completely controlled from human disturbance since July 1952, and is considered a treasure house of ecosystems inhabited by various living creatures. However, the DMZ is now threatened by many factors and can no longer be safely treated as a treasure house. Overland routes are opened to promote inter-Korean reconciliation, economic cooperation and cultural and tourist exchanges, making traffic between South and North Korea frequent. The onset of threats to the DMZ requires the development of an efficient conservation and management plan as soon as possible.

To this end, the DMZ 2 km wide south of the Military Demarcation Line needs to be surveyed and analyzed in detail. However, a systematic and detailed survey of the DMZ is yet to take place. A study team led by the senior author conducted a UNDP ecological survey (UNDP-SNU 2000) of the western DMZ and Civilian Controlled Area (CCA). The ecological survey was conducted as an impact assessment focused on Paju in the wake of the restoration of the Gyeongui Line (Kyungeui inter-Korea Road Joint Environment Survey Team 2001) and the Donghae Line and the construction of inter-Korea roads (Korea Rail Network Authority 2004). In addition, intermittent ecological surveys took place over the iron fence. A document that synthesizes these data organically to suggest

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habitats and species prevalent in the DMZ is still unavailable.

Every idea and plan for development should be preceded by precise, scientific and systematic surveys and analyses of a target area. As a scholar specializing in environment and ecology planning, the author regrets that much discussion of development is taking place with no support from comprehensive and systematic surveys and analyses of the ecological resources of the DMZ and their functions and values.

Materials and methods

Site description

The DMZ, which is 248 km long from west to east and 4 km wide, covers an area of 907 km² and lies across the central part of the Korean Peninsula. The CCA is the northern part of Civilian Controlled Line. Its width ranges from 5 km–20 km from the Southern Limitation Line and its area is 1,369 km². Also, under the Trans-boundary Area Support Law, which was approved in 2000, the southern portion of the CCA has been designated as a trans-boundary area. Its area is 7,678 km². Excluding the trans-boundary area, the ecosystem treasure house running across the Korean Peninsula covers about 2,276 km² (See Fig. 1).

Data and field survey methods

The status of ecological resources of the DMZ are presented based on the outcome of a UNDP Project (1996–1999) led by the senior author (UNDP-SNU 2000), field visits facilitated by the Joong-ang Daily News (2000) and the Seoul Daily News (2004), a survey of natural ecosystems in an area adjacent to the DMZ (Goseong

county 2002), and surveys completed in the wake of the construction of the Gyeongui Line, the Donghae Line and inter-Korean roads.

Value assessment methods

The value of ecological resources of the DMZ is assessed based on surveys and analyses conducted so far. Although the DMZ has always been quoted as a treasure house of ecosystems, it has not been well examined according to specific criteria. Therefore, in this paper the conservation value of the DMZ will be assessed according to Prime Biodiversity Areas (PBAs) and other internationally recognized criteria, including criteria put forth by the IUCN (1997), RAMSAR and UNESCO (2000). However, all results of this assessment are to be considered tentative as surveys are not yet sufficient.

Results

Status of habitats of DMZ and CCA

As suggested in the introduction, the DMZ and CCA have a number of diverse habitats. Studies to date have mostly focused on the distribution of species in the DMZ and CCA, with little emphasis placed on the systematic review of habitats. Therefore, this paper seeks to provide, in a comprehensive manner, the status of diverse habitats observed in the DMZ. Habitat details are described in Table 1. Criteria for habitat classifications follow Sutherland and Hill (2002).

Meanwhile, as for ecosystems based on topography, these habitats show wetland ecosystems, forest ecosystems, grassland ecosystems, farmland ecosystems, waterbodies, and coastal ecosystems observed around the area.

Fig. 1 DMZ and CCA geography

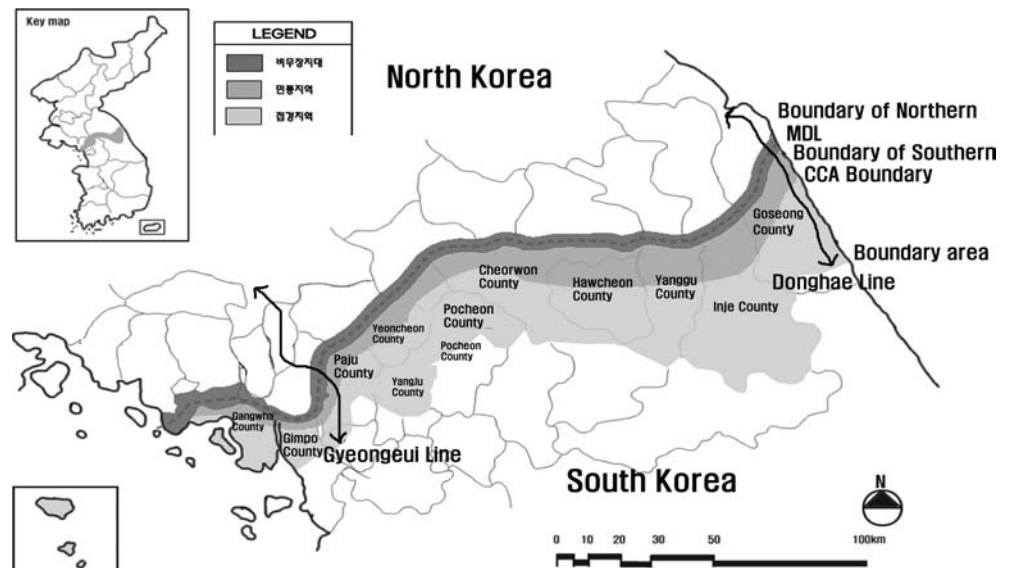


Table 1 DMZ habitat overview table (tentative)

Habitat classification	Target area within the DMZ
Coastal habitats	
The open sea and subtidal habitats	Gimpo tidal flats, Gangwha tidal flats, etc.
Rocky shores	Yudo, etc.
Sandy shores and estuaries	Hangang estuary, Gimpo Wolgot, Eastern coast estuary, etc.
Coastal lagoons	Gamho, Hwajinpo, Yeongrang Lake, etc.
Sand-dunes	Sweetbrier communities along the eastern coastline, etc.
Salt marshes	Wetlands along the Han River estuary, etc.
Shingle	NA
Sea cliffs	Eastern coast cliffs, etc.
Sea walls	NA
River habitats	Imjin River, Hantan River, Sacheon River, Sami Stream, Yeokgok Stream, Nam River, Bukhan River, Sewol Stream, Myeolgong Stream, Seongnae Stream, Suip Stream, etc.
Water-bodies	Eoryong Reservoir, Hak Reservoir, Togyo Reservoir, Sanmyeong Lake, An Lake, Paro Lake, etc.
Wetlands	
Forested wetlands	Gojindong Valley in Goseong county, forest valley in Dutayeon, Bangchuk-dong in Paju, forested wetlands from Baekhak Paju to Pilsung Bridge in Cheorwon, every riverside, etc.
Reedbeds	Samtong in Cheorwon, Paju Story Shooting Range, abandoned rice paddies, rivers, etc.
Peatlands	Peatlands in Geyoneui Line, Yong neub, etc.
	Between Ojak Bridge and Andongpo Bridge, Paju Story Shooting Range, etc.
Grassland	
Acid grasslands	NA
Mesotrophic grasslands	NA
Calcareous grasslands	NA
Farmland	Gimpo Plain, Gangwha agricultural land, Paju agricultural land, Cheorwon Plain, Yeoncheon agricultural land, and Goseong agricultural land, etc.
Natural wood-land and scrub	
Tree communities	
Coniferous	Geonbong Mountain, Hyangro Peak, Daeam Mountain, Baekam Mountain, etc.
Broad-leaved	Gachil Peak, Dosol Mountain, Daewu Mountain, Gajeon-ri, Daeseong Mountain, Dora Mountain, Baekhak Mountain, and forest around Baekma Height
Ground flora	NA
Epiphytic flora and fungi	NA
Coppice	Goseong and Yanggu forest fire areas, etc.
Scrub succession	Goseong and Yanggu forest fire areas, etc.
Urban areas	Villages scattered in Daesong-dong and CCA in Paju

NA not available

Status of wetland ecosystems

Wetlands in the DMZ and CCA are much more diverse and extensive than is commonly thought. Due to a higher concentration of lowlands, wetlands are more diverse in the western portion of the DMZ than in the eastern portion of the DMZ. Valley wetlands and lacustrine wetlands are mainly observed in the eastern area.

Tidal flats are well developed in the Gangwha and Gimpo areas due to their adjacency to the western coast. Eleven inhabited islands and 17 uninhabited islands maintain habitats conducive to the coastal bird populations they sustain. An area presumed to be peatland was found in the DMZ near the Gyeongui Line railway path in Paju. In addition, riverine wetlands created by the Imjin River and the Sacheon River were distributed extensively in the western area of the DMZ.

In the Yeoncheon area, riverine wetlands and palustrine wetlands are located extensively around the Sami

Stream. In particular, the Sami Stream, which originates from North Korea, is an important site offering an image of undestroyed, natural habitat within the DMZ. Abandoned rice paddy wetlands and forested wetlands are well developed around the Paju Story Shooting Range. Also, wetlands of various sizes are interspersed around the Eoryong Reservoir, the Han River estuary, the Myeolgong Stream, and the Sewol Stream. Reservoirs, lakes and farmlands occupy Cheorwon county in the central part of the DMZ. Hydrologic resources include Togyo Reservoir, Hak Reservoir and Sanmyeong Lake. Cheontong is a wetland biotope with a high conservation value inhabited by *Hydropotes inermis*. In addition, wetlands created in a process of succession of agricultural land to abandoned rice paddies and natural wetlands are distributed extensively and serve as a home of various wild animals. The Hantan River and the Namdaecheon Stream wetlands also support important species.

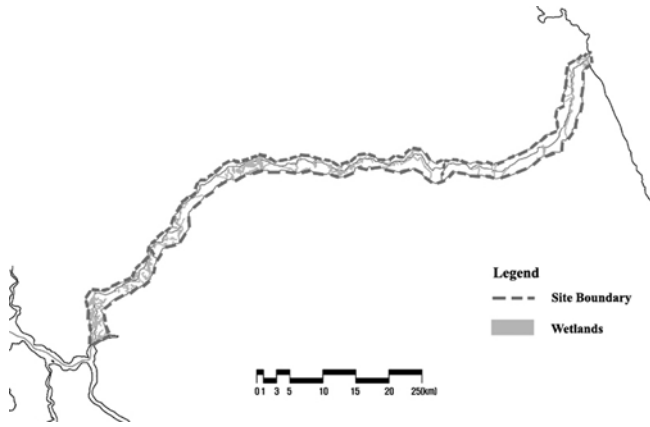


Fig. 2 Wetland ecosystems in the DMZ. (Kim 2003a, b; Ku and Kim 2001)

Yong neub, a high peatland located on Daeam Mountain, is situated on the boundary between Yanggu county and Inje county. Due to its unique biota and ecology, Yong neub has been designated as an ecosystem conservation area, a wetland protection district, and a natural monument by the Ministry of Environment (2003). It is also a registered Ramsar Site. In Hwacheon county, lowlands near Daeseong Mountain and wetlands developed in valleys form various plant communities. Natural riverine wetlands are preserved in the Naerin Stream in Inje county. Diverse wetlands including forested wetlands, riverine wetlands, coastal wetlands, lacustrine wetlands, and palustrine wetlands are observed in Goseong county (2002). Coastal wetlands are particularly well developed in Goseong county (2002), and they include what is estimated to be the largest *Rosa rugosa* community in Korea. This community extends from the front of the Unification

Observation Deck, across the Military Demarcation Line, and to the sand dunes that continue to Guseon Peak. Hwajinpo and Gamho, which are the largest lagoons on the eastern coast, contribute additional resources by serving as migratory bird habitat.

Status of forest ecosystems

Topographically, forest ecosystems are most prominent in steep terrain. Geographically, they range from the eastern DMZ to the Cheorwon Plain. Based on prevalent vegetation, forests can be classified into four classes—coniferous forest, broad-leaved forest, mixed forest, and scrub.

Major forest ecosystems observed in the DMZ and CCA have been mapped in Fig. 3.

The western portion of the DMZ and CCA maintains an attractive forest environment that has formed on relatively low hills and islands. Forest ecosystems near Panmunjeom and forests on low hills around Dora Mountain and Baekhak Mountain maintain connectivity with water resources, wetlands and grasslands, and serve as habitat for a number of species. Forest vegetation characteristic of post-disturbance succession is observed in hilly areas in Cheorwon and in an area around the Baekma Heights Observation Deck. The area is broadly dominated by *Quercus mongolica*. Some species that are presumed to have been intentionally planted, which are found sporadically, include *Castanea crenata* var. *dulcis*, *Pinus densiflora* and *Pinus koraiensis*. Military exercises, including forest fires intentionally set for visibility improvement, frequently disturb vegetation in and adjacent to the DMZ in Yanggu and Goseong counties. This continued forest disturbance has yielded simple forest biota, which includes shrub areas and forest stands delayed in their development. On Gachil Peak, Dosol

Fig. 3 Major forest ecosystems in the DMZ and CCA

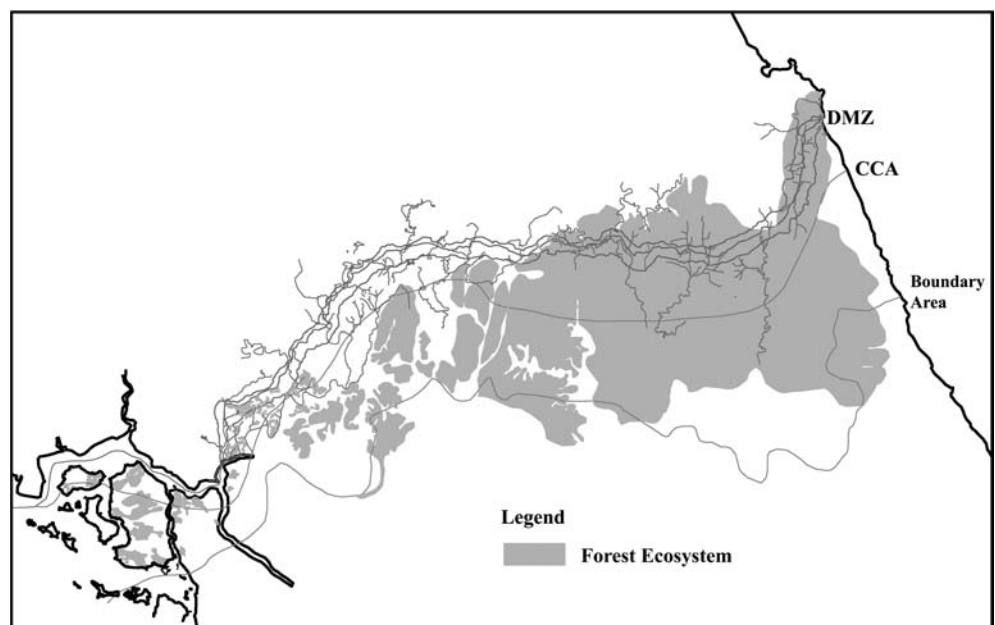


Table 2 Overview of results from the species survey in the DMZ and CCA

Survey conductor	Survey area	Survey period	Survey method	Survey result	CCA
KFRI (KFRI 2000)	Major forests, valleys, rivers, and islands in CCA	1995–2000	Both literature survey and field survey	DMZ	Total: 1,866 species - Plants: 1,194 species - Animals: 672 species - Mammals: 52 species - Birds: 201 species - Amphibians and reptiles: 28 species - Freshwater fish: 67 species - Insects: 324 species Total: 699 species - Plants: 470 species - Animals: 229 species - Mammals: 11 species - Birds: 58 species - Amphibians and reptiles: 22 species - Freshwater fish: 24 species - Insects: 114 species
UNDP, SNU (UNDP-SNU 2000)	DMZ: Eoryong reservoir in DMZ, Panmunjom area in DMZ, upstream portion of the Sacheon River and surrounding wetlands located in the DMZ - CCA: Jangdan Peninsula in Paju, Dukhyun-dong Jangdan-myong Paju, Joong-dong Jindong-myong Paju, Bangchuk-dong Jindong-myong Paju, Dowha-dong Gunnae-myong Paju DMZ: Dorasan-ri Paju, Ha-dong Paju, Gubongcheon Jangdan-myong Paju - CCA: Baikyeon-ri Gunnae-myong Paju, Gunryang-dong Gunnae-myong Paju	1996–1999	Focused on field survey	Total: 87 species - Plants: 31 species - Animals: 56 species - Mammals: 2 species - Birds: 14 species - Amphibians and reptiles: 5 species - Freshwater fish: 15 species - Insects: not surveyed	
Environment joint-survey team for Gyeongui inter-Korean Road (Gyeongui inter-Korean Road joint survey team 2001)	DMZ: Dorasan-ri Paju, Ha-dong Paju, Gubongcheon Jangdan-myong Paju - CCA: Baikyeon-ri Gunnae-myong Paju, Gunryang-dong Gunnae-myong Paju	25 Sept to 1 Dec 1999	Both literature survey and field survey	Total: 259 species - Plants: 183 species - Animals: 76 species - Mammals: 4 species - Birds: 32 species - Amphibians and reptiles: 10 species - Freshwater fish: not surveyed - Insects: 30 species	Total: 312 species - Plants: 225 species - Animals: 87 species - Mammals: 5 species - Birds: 39 species - Amphibians and reptiles: 16 species - Freshwater fish: 7 species - Insects: 20 species
Environmental Impact Survey of Gyeongui inter-Korean Road (Gyeongui inter-Korean Road joint survey team 2003)	- DMZ: Dorasan-ri Paju, Ha-dong Paju, Gubongcheon Jangdan-myong Paju - CCA: Baikyeon-ri Gunnae-myong Paju, Gunryang-dong Gunnae-myong Paju	June 2001 to 2003	Both literature survey and field survey	Total: 434 species - Plants: 183 species (Community survey only) - Animals: 251 species - Mammals: 4 species - Birds: 32 species - Amphibians and reptiles: 4 species - Freshwater fish: not surveyed - Insects: 211 species	Total: 497 species - Plants: 225 species (Community survey only) - Animals: 272 species - Mammals: 2 species - Birds: 35 species - Amphibians and reptiles: 2 species - Freshwater fish: 22 species - Insects: 211 species

Table 2 Continued

Survey conductor	Survey area	Survey period	Survey method	Survey result	DMZ	CCA
Gyeongju Line post-impact assessment survey	- DMZ: Dorasan-ri Paju, Ha-dong Paju, Gubongcheon Jangdan-myon Paju - CCA: Baikyeon-ri Gunnae-myon Paju, Gumryang-dong Gunnae-myon Paju	July 2004 to present	Field survey	Total: 463 species - Plants: 196 species - Animals: 267 species - Mammals: 14 species - Birds: 32 species - Amphibians and reptiles: 4 species - Freshwater fish: 6 species - Insects: 211 species		
Survey of natural ecosystems in an area around the DMZ (Goseong county 2002)	- CCA and some DMZ: CCA from Songhyun-ri Gangwon Province to Southern Limiting Line fence, a section of 4.7 km south-north, 4.4 km-wide	15 Oct 2001 to present	Field survey	Total: 357 species - Plants: 288 species - Animals: 69 species - Mammals: 10 species - Birds: 31 species - Amphibians and reptiles: 18 species - Freshwater fish: 10 species - Insects: not surveyed		

Mountain, Daeu Mountain and in the Gajeon-ri area, vegetation is dominated by broad-leaved shrubs. Forest stands in Dutayeon, on Geonbong Mountain and in the Hyangro Peak area are well developed. The Hyangro Peak area is particularly mountainous and serves as a watershed creating and east to west division. Steep topography links ecosystems on Chiljeol Peak, Hyangro Peak and Geonbong Mountain. These areas are assessed to be preserved in their natural state.

Status of grassland ecosystems

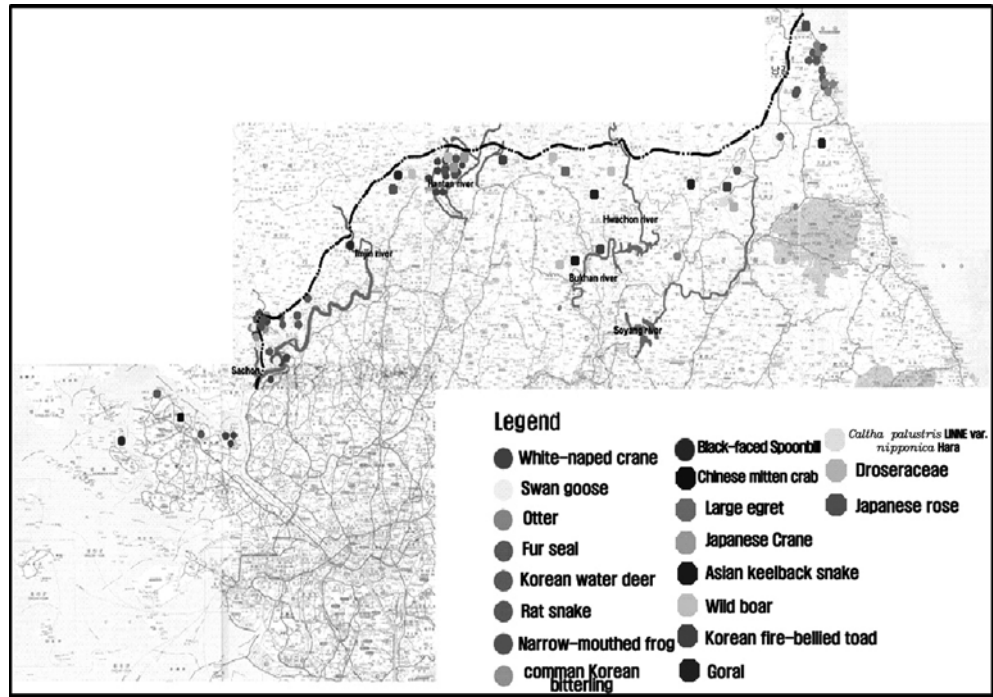
Some grassland habitats within the DMZ are restricted from successional progression due to frequent disturbances such as intentional fire attacks and natural forest fires. Grassland communities defined by the dominance of *Potentilla fragarioides* var. *major*, *Erigeron canadensis* or *E. annuus*, and *Miscanthus sinensis* var. *purpurascens* are easily observed on the levees of rice paddies, in fields and on mountains in the DMZ. Although it is difficult to determine how much grassland exists in the area, the ecosystem is regarded to be important in promoting biodiversity between wetlands and forest areas. Grasslands in low, flat areas are distributed throughout the western region of the DMZ and CCA. Alpine grasslands present at high elevations and bottomland-grasslands are present in the central and eastern regions. In Chorwon county, vast grasslands are present in gently sloping lowlands and at the margins of nearby agricultural land. These areas are inhabited by *Physalis alkekengi* var. *francheti*, *Commelina communis*, *Geranium sibiricum*, and *Chelidonium majus* var. *asiaticum*. The alpine grasslands more common in the eastern portion of the DMZ maintain rather weak communities dominated by *P. fragarioides* var. *major* and *Viola mandshurica*. *Caltha palustris* var. *membranacea* communities and *Duchesnea chrysantha* communities are present on the summit of Hyangro Peak. Highly dispersed *M. sinensis* var. *purpurascens* communities are also present in the DMZ.

Status of species in the DMZ and CCA

Species status, which has been determined by synthesizing data for species confirmed to be living in the DMZ and CCA, literature records, and surveys actually conducted by the senior author, is summarized in Table 2. Field surveys were limited due to circumstantial constraints such as land mines and restricted access. Therefore, a detailed ecological survey, if conducted, would likely yield many more species than described here. Moreover, the number of reported species would likely further increase if future surveys incorporate portions of the DMZ located in North Korea.

The incomplete nature of the results presented in Table 2 stress that, above all, it is very important for South Korea and North Korea to jointly conduct a detailed and well-structured ecological survey on the

Fig. 4 Distribution of major species in the DMZ and CCA



DMZ and CCA. The distribution of major species is shown in Fig. 4.

Assessing the value of ecological resources of DMZ

Assessing conservation value according to PBAs

Key or PBAs refer to sites with especially high measures of biodiversity. In general, PBAs exhibit a distribution

of wildlife and biogeographic features representative of natural conditions. High species diversity and distribution within the DMZ enable assessment of conservation value through the identification of PBAs in the region. The general process and details regarding conservation value assessment, in accordance with PBAs, is shown in Fig. 5.

Criteria for the assessment of PBAs, including size and diversity, are defined at a macro-level. Various other criteria, which are defined at sub-levels, include habitat size, species richness, diversity, distinctive habitat formats, and unique habitats.

The results of an assessment applying the criteria mentioned above to a few sites where basic surveys were possible within the DMZ and CCA are shown in Table 3.

As described in Table 3, when conservation value was assessed based on data presently available, Chopyeong Island in Paju, the Gyeongui Line section, the Sami Stream, the Sewol Stream, the Yeokgok Stream in Cheorwon, the Seongnae Stream in Hwacheon, the area around Dutayeon, Hyangro Peak, and the Donghae Line section appear to be high priority PBAs.

Assessing conservation value according to criteria suggested by international organizations

Unlike the conservation value assessment described above, the purpose an assessment according to criteria suggested by international organizations is to have the natural ecology of the DMZ protected and designated or, at least, recognized internationally. For this paper, the DMZ was assessed tentatively using criteria sug-

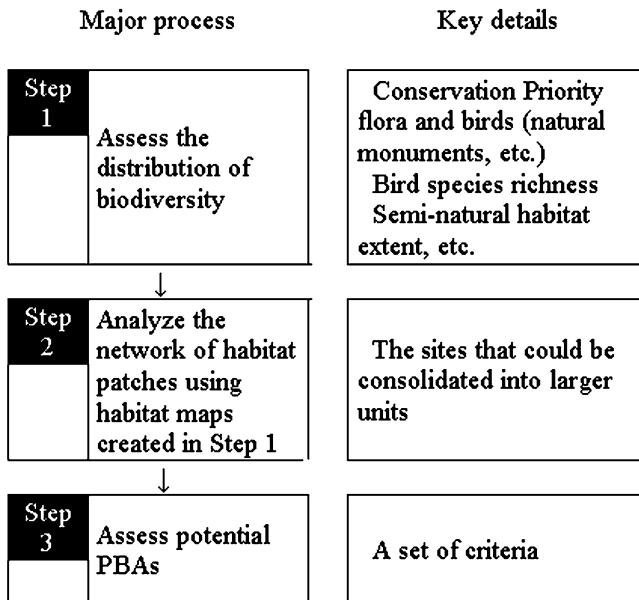


Fig. 5 Process of assessing PBAs

Table 3 Assessment table for PBAs on major sites that may be surveyed

Survey sites	Assessment criteria												
	Railway & road construction project area	Area where restoration is raised as an issue (Under threat)	Areas with unique habitats								Areas		
			Rivers	Wetlands					Forest	Grassland	Estuary	Sand dune	Reservoirs
			Estuary	Palustrine	Lacustrine	Riverine	Forested	Peat land					
Gimpo Wolgot			<input type="checkbox"/>				<input type="checkbox"/>				<input type="checkbox"/>		
Sachon Stream tributaries in Paju							<input type="checkbox"/>						
Gyeongui Line in Paju	<input type="checkbox"/>	<input type="checkbox"/>						<input type="checkbox"/>					
Chopyeong Island Paju				<input type="checkbox"/>			<input type="checkbox"/>				<input type="checkbox"/>		<input type="checkbox"/>
Sami Stream Yeoncheon			<input type="checkbox"/>										
Sewol Stream Yeoncheon			<input type="checkbox"/>										
Mountainous wetland communities from Baikhak				<input type="checkbox"/>			<input type="checkbox"/>			<input type="checkbox"/>			
Paju to Pilseung Bridge in Cheorwon				<input type="checkbox"/>						<input type="checkbox"/>			
Area Pilseung Bridge in Cheorwon				<input type="checkbox"/>			<input type="checkbox"/>			<input type="checkbox"/>			
Yeokgok Stream, Cheorwon			<input type="checkbox"/>										
Cheorwon Plain wetland	<input type="checkbox"/>												
Sanmyeong Lake, Cheorwon	<input type="checkbox"/>				<input type="checkbox"/>								<input type="checkbox"/>
Togyo (Samtong) Cheorwon	<input type="checkbox"/>												
Ojak Bridge, Hwacheon (Andongpo Bridge ↔ Ojak Bridge)	<input type="checkbox"/>						<input type="checkbox"/>						
Hwacheon 504OP				<input type="checkbox"/>				<input type="checkbox"/>		<input type="checkbox"/>			
Yong Swamp, Daeam Mountain, Yanggu	<input type="checkbox"/>							<input type="checkbox"/>		<input type="checkbox"/>			
Suip Stream, Yanggu			<input type="checkbox"/>										
Seongnae Stream, Hwacheon			<input type="checkbox"/>										<input type="checkbox"/>
Hugok mineral fountain, Yanggu				<input type="checkbox"/>									
Donghae Line	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>									<input type="checkbox"/>
Around Dutayeon			<input type="checkbox"/>	<input type="checkbox"/>			<input type="checkbox"/>			<input type="checkbox"/>			
Hyangro Peak	<input type="checkbox"/>			<input type="checkbox"/>			<input type="checkbox"/>			<input type="checkbox"/>			
Nam River (Gojin-dong valley)			<input type="checkbox"/>	<input type="checkbox"/>			<input type="checkbox"/>			<input type="checkbox"/>			
Nam River (Oso-dong valley)			<input type="checkbox"/>	<input type="checkbox"/>			<input type="checkbox"/>			<input type="checkbox"/>			
Others													
Dora Mountain observatory deck, Paju	<input type="checkbox"/>												
Yeolsoe Observatory deck, Yeoncheon													
Taepung Observatory deck, Yeoncheon													
Woljeong Observatory Deck, Cheorwon	<input type="checkbox"/>												
Unification Observatory Deck, Goseong	<input type="checkbox"/>												
Peace Dam	<input type="checkbox"/>												
Uninhabited islands													

gested in the IUCN (1997) Red Data Book, for Ramsar Sites, by the International Peat Society, by the UNESCO (2000) Natural Heritage program and for Transboundary Biosphere Reserves.

Assessing value according to the IUCN (1997) Red Data Book The Red Data Book by the IUCN (1997) provides basic data on the status of endangered species by identifying the worldwide distribution of important

wildlife for the purpose of preventing species extirpation (http://www.iucn.org). In addition, it aims to provide information for sustainable conservation through the restriction of destructive activities. About 70 important wild animal species found in Korea are included in the Red Data Book. Among the species listed in the Red Data Book, those observed in the DMZ are shown in Table 4.

Table 4 Result of value assessment according to the Red Data Book (tentative)

Items	Species found in the DMZ
Mammals	<i>Hydropotes inermis</i> <i>Felis bengalensis manchurica</i> <i>Moschus moschiferus parvipes</i> <i>Nemorhaedus goral raddeanus</i> <i>Sciurus vulgaris coreae</i>
Birds	<i>Grus japonensis</i> <i>Grus vipio</i> <i>Grus monacha</i> <i>Aegypius monachus</i> <i>Anser cygnoid</i> <i>Platalea minor</i> <i>Haliaeetus albicilla</i> <i>Tringa guttifer</i> <i>Numenius madagascariensis</i> <i>Chinese black-headed gull</i> <i>Aquila heliaca</i> <i>Eurynorhynchus pygmeus</i> <i>Haliaeetus pelagicus</i> <i>Locustella pleskei</i> <i>Megalurus pryeri</i>
Amphibians and reptiles	DD Species
Insects	DD Species
Plants	DD Species

DD data deficient

detailed ecological surveys, the wetlands should be officially recognized as an area of international ecological importance, and should be protected accordingly.

Assessment according to criteria put forth by the International Peat Society Peatlands or mires are wetland

ecosystems that are characterized by the accumulation of organic matter that is produced and deposited at a greater rate than is decomposed, leading to the formation of peat. Peatlands play an important role in the biosphere. They interact with fundamental life-support processes, involving biogeochemical cycling, food-chain support, hydrological dynamics and water quality, and provide habitats for many characteristic (and some highly adapted) plant and animal species. Peatlands within the DMZ and CCA have a few distinct features. Criteria for peatland, which is considered an internationally important wetland ecosystem, and the assessment results for peatland in the DMZ according to these criteria, are reported in Table 6. Assessment of peatlands requires a significant number of field surveys and analyses. Therefore, there should be future surveys of the peatland in the DMZ.

Criteria for designation as a UNESCO World Natural Heritage site The World Heritage Committee was launched at the UNESCO General Conference in 1972 in order to restore, protect and preserve the world's natural and cultural heritage sites that, despite their internationally high value, have been deserted and are on the verge of ecological deterioration, destruction or extinction (<http://www.unesco.org>). Natural Heritage refers to sites with high global conservation value that are designated by UNESCO (2000) according to the "World Heritage Convention". Sites qualified for designation as Natural Heritage include those showing a stage of the earth's evolutionary processes, or unique kinds of physical and geologic formations, or are rep-

Table 5 DMZ value assessment results according to Ramsar Site Criteria (tentative)

Criteria	Potential sites within the DMZ	Remarks
Group A Representative or unique wetlands	Wetlands in the entire DMZ Yong neub in Daeam Mountain	Designated as a Ramsar Site
Group B Criteria based on species and ecological communities Specific criteria based on waterbirds	Wetlands in Gangwha, Paju, and Cheorwon Wetlands in Paju and Cheorwon inhabited by the Japanese Crane, Gyodongdo in Gangwha and Yudo in Gimpo inhabited by the black-faced spoonbill	
Specific criteria based on fish	Tidal flats and estuary wetlands in Gangwha	

Table 6 The results of a value assessment according to the International Peat Society Criteria (tentative)

Criteria	Key potential sites in the DMZ	Remarks
Where peat accumulates over hundreds, or thousands, of years Where depths are at least 45 cm and where depths range from 2 m to 12 m	Yong neub in Daeam Mountain	The depth of a peat layer cannot be actually measured in many sites within the DMZ
Undrained peat consisting of 95% water and 5% solid material	Natural wetlands created through succession of abandoned rice paddy wetlands	
Types of peatlands are fens or bogs	Yong neub in Daeam Mountain and wetlands next to Gyeongui Railway	

representative of biological evolution, or contain the natural habitats of endangered animals. It may be a scene of exceptional beauty or a reserve for large numbers of wild animals. Based on these criteria, 149 Natural Heritage sites have been designated to date. The results of a DMZ assessment completed using UNESCO (2000) Natural Heritage designation criteria are shown in Table 7. As shown in Table 7, most of the DMZ appears to meet criteria for designation as a World Natural Heritage site. Therefore, more detailed examination and verification efforts should take place in the future. Then, based on the results, specific plans to designate the DMZ as a World Natural Heritage site should be developed.

Criteria for designation as a UNESCO Trans-boundary Biosphere Reserve In order to protect and manage major habitats in the DMZ at an international level, they may be designated as Ramsar Sites according to the Ramsar Convention. Additionally, areas within the

DMZ may also be designated as UNESCO Trans-boundary Biosphere Reserves (TBR). TBRs refer to areas designated by UNESCO (2000) for the purposes of conserving biodiversity, developing communities and preserving cultural value. Results from an assessment of the DMZ using TBR criteria are shown in Table 8. In this table, requirements for designation as a biosphere reserve include (1) an ecosystem representing a biogeographic region, (2) an area containing a variety of species and habitats to be conserved, (3) an area where a concept of sustainable development can be applied, and (4) an area where public institutions, regional communities, and private sectors may participate. The DMZ and CCA meet all criteria suggested above and are rich in ecological diversity and functions. Therefore, South Korea and North Korea should make joint efforts to designate the DMZ and CCA as a TBR.

Table 7 Results of the DMZ value assessment according to the UNESCO (2000) World Nature Heritage Criteria (tentative)

Criteria	Potential Sites in the DMZ	Remarks
Earth's evolutionary processes (or representative of biological evolution)	Rice paddy wetlands (the entire DMZ) Peatlands (Daeam Mountain and Gyeong eui Line) Burned forests (Goseong, Cheorwon, etc.)	
Natural habitat	Wetlands (entire area) Quality forest (in particular, quality forests in the eastern part of the DMZ)	
Endangered animals	<i>Nemorhaedus goral raddeanus</i> <i>Grus japonensis</i> <i>Moschus moschiferus parvipes</i> , etc.	
A scene of exceptional beauty (or, a spectacular view)	Hyangro Peak Geonbong Mountain Daeseong Mountain Daeam Mountain Baekam Mountain etc.	
A reserve for large numbers of wild animals	Wetlands (entire area) Major rivers and streams (Imjin River, Nam River, Sacheon River, Sewol Stream, Myeolgong Stream, etc.) Major forests in the eastern area such as Hyangro Peak and Geonbong Mountain	Sites considered to be PBAs in Table 3
Physical and geologic formations	Columnal joints (Hantan Riverside, Imjin Riverside) Limestone caves (Sangmeori in Cheorwon)	

Table 8 Results of a value assessment of the DMZ according to the UNESCO TBR Criteria (tentative)

Criteria	Approach
Span the territories of two or more nations while maintaining spatial continuity	As the DMZ is situated traversing South and North Korea, this criterion may be applied to the entire area. As a result, the entire DMZ may be approached for designation as a transboundary biosphere reserve.
Meet the requirements for designation as a biosphere reserve	The DMZ may be designated as a biosphere reserve because it maintains high species diversity. Sites where particularly important species are located may be approached individually.
Economic, tourism, cultural and personnel exchanges take place between transboundary nations	In areas where the Gyeongui Line and Donghae Line pass through the DMZ, economic, tourism, and cultural exchanges take place between South and North Korea. These areas may be considered for designation first.
Develop a joint management plan and a mechanism to adjust the regional functions of each nation	In the future, a joint management plan with North Korea needs to be developed. Designation of TBRs in relevant areas may be approached.

Discussion

This paper has reviewed, using various methods and criteria, the present status of natural ecosystems, habitats and species in the DMZ and CCA.

In terms of ecosystems and habitats, it was confirmed that diverse forest vegetation, water bodies, grasslands, farmlands and wetland types comprise the landscape from the eastern mountainous area to the western low wetland area. It was also confirmed that ecological succession continues in the ecosystems of the DMZ and CCA despite partial disturbance by humans.

In terms of species, according to the Comprehensive Report on the Ecological Survey of the DMZ released by the Ministry of Environment (2003), biota in the DMZ and adjacent areas include 1,597 plant species (34% of all plants of the South Korea), 106 fish species (12% of fish species of the South Korea), 29 amphibian and reptile species (71% of all amphibians and reptiles of the South Korea), 201 bird species (51% of all birds of the South Korea), and 52 mammalian species (52% of all mammals of the South Korea).

Results of conservation value assessments of the DMZ, completed using criteria from the IUCN (1997) Red Data Book, Ramsar Site criteria, International Peat Society criteria, UNESCO (2000) Natural Heritage and TBR criteria and PBA criteria, confirm that the DMZ and CCA are ecosystem treasure houses to be recognized internationally. In terms of habitats and species, the tentative conservation values of tidal flats in Gyodongdo in Gangwha, Yudo in Gimpo, Chopyeong Island and Eoryong Reservoir, the Sacheon River, areas adjacent to the Gyeongju Line, the Sewol Stream, the Myeongong Stream, the Choelwon Plain, Togyo Reservoir, the Yeokgok Stream, Geonbong Mountain, Hyangro Peak, Baekam Mountain, Daeseong Mountain, and sand dunes in the eastern coast appear to be high. Although this is a tentative assessment, which was completed without a DB or systematic surveys and analyses, the DMZ and neighboring CCA maintain ecosystems assessed to be important using criteria that suggest international recognition.

Although the economic welfare and the quality of life of Koreans are heavily dependent on natural resources including wetlands and forests, it has been observed that the DMZ and CCA have been damaged to the extent that significant wetland and forested areas have been lost. Therefore, habitats that do remain are even more valuable.

From this point forward, in order to preserve wetlands and forests for the sake of all species and that of this and future human generations, South Korea and North Korea should cooperate proactively to take actions protecting natural ecosystems. To this end, it is necessary to decide area-specific conservation values and to develop a comprehensive plan for environmental management based on sound scientific and systematic ecological surveys.

In order to realize this, a DMZ South-North Korean Environment Cooperation Committee should be set up, and a joint study of ecological resources within the DMZ should be conducted with an international organization. Also, efforts for the designation of the DMZ as a UNESCO TBR, a World Natural Heritage or Cultural Heritage site, and as a Ramsar Site as proposed by President Kim Dae-joong, should be exerted. In particular, an environmental impact assessment of the northern part of Gyeongju inter-Korean road, Mt. Geumgang road, and inter-Korean railway restoration should be conducted. The two Koreas should work together in setting alternatives that will minimize impact on ecosystems and seeking actions to reduce impact. Through such efforts, natural ecosystems in the DMZ and CCA may be seen as a benchmark where an environmentally sound and sustainable international management model is applied.

Based on details and key conclusions presented in this paper, a few ideas that may be helpful for the efficient future conservation and management of the DMZ are suggested.

Firstly, additional surveys on wetlands should be conducted as surveys on the DMZ have so far focused on forest ecosystems. Wetland classification and mapping, wetland species surveys, and assessments of their functions and values should be conducted in a systematic and scientific manner. To this end, it would be reasonable to include the DMZ in the Nation-wide Wetland Survey Project initiated by the Ministry of Environment (2003) as a UNDP/GEF project.

Secondly, a DMZ habitat management plan should be developed. In advanced nations such as the UK and the USA, habitat management plans need to be developed for environmentally sensitive areas such as the DMZ. Therefore, a habitat management plan should be developed, albeit in phases, for the DMZ. The plan should go beyond the level of simple conservation by including wetland restoration with compensatory mitigation policies.

Lastly, a World Heritage List Application needs to be prepared in accordance with the World Heritage Convention. Through discussions with relevant ministries, the Application (A) should be prepared by applying the World Heritage Convention criteria. Then, it would be desirable to refine it through additional surveys and studies.

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