

The Current Status of Ecosystem Diversity in Korea and Conservation Strategy

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우리 나라 생태계 다양성 현황과 보전전략

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요 약

보전전략은 규모가 큰 지역을 설정하여야 하는 데 그 이유는 광역보전지역은 다양한 생물지리학적 분포를 포함할 수 있기 때문이다. 이런 관점에서 본 보고서는 우리 나라의 다섯 개의 중요한 생태계에 대하여 기술하였다. 다섯 개의 생태계는 산림생태계, 담수생태계, 연안 및 해양 생태계와 도서생태계 그리고 비무장지대생태계이다. 각각의 생태계 보전전략에 대해 물리적인 측면과 생물지리적 측면에서 기술되었으며 생태계 보전방안은 생태계의 기능과 가치뿐만 아니라 자연시스템을 유지하고 복원하는 데 매우 유리하다. 생태계 보전을 위해 1) 지역주민에게 인센티브를 제공하고, 2) 연구와 교육 및 홍보의 기능을 강화하며, 3) 지역정보와 기술을 상호 교환하고, 4) 국제협력 증진을 도모, 5) 보전지역을 조성하기 위한 예산확보를 제안하였다.

주요어 : Ecosystem, Conservation Strategy, Ecosystem Diversity, Biogeographic, Demilitarized Zone, Korean Peninsula

I. Introduction

Natural ecosystem is a dynamic system that is composed of both biotic and abiotic factors. Since it provides us with shelters as well as various resources that living organisms depend on it is invaluable. Life supporting natural ecosystem

should produce, consume, and compose within a system so that circulation of material can be maintained. Natural ecosystem that has been maintained in balance and harmony is challenged by environmental deterioration by human.

Since 1992 Rio Conference biodiversity or biological diversity has been emerged as one of the

key subjects for the 21st century for the mankind because we have to understand biological species on earth as resources for existence so that the wealth of each country can be evaluated depending on the number of biological species. The Korean peninsula has been known as one of the best places in scenery on earth and rich in biological resources. The Korean peninsula belongs to the Palaearctic biogeographic realm and divided into two districts of highland and lowland. South Korea supports a biota that includes 100 species of mammals, 394 birds, 15 amphibians, 26 reptiles, 905 fishes, 11,853 insects, 1,172 spiders and other invertebrates of 2,361 species, 3,971 vascular plants, and 4,300 species of non-vascular plants including bryophyte and algae and 1,128 species of fungi (Ministry of Environment, 1996). In this regard this paper describes the major ecosystems in the Korean peninsula that supports over 20,000 living organisms and sets up conservation strategies for each major ecosystem.

II. Major Ecosystems in the Korean Peninsula

The Korean peninsula is long and irregular in shape with a north-south axis separating the shallow Yellow sea from deeper East sea. With its affiliated islands it lies between 124°11'E and 131°53E, and between 33°06'N and 43°01'N and it shores a border with China and Russia. The total area of the peninsula is 221,489 km², although Demilitarized Zone (DMZ) currently divides North from South Korea. South Korea is relatively small of 99,117 km² which is almost 45% of the total area of the peninsula. As the Korean Peninsula harbors diverse geographical regions

so are major ecosystems. There are five major ecosystems in Korea ; forests, freshwater, coastal, island ecosystems, and ecosystem in DMZ. Each ecosystem has its value and conservation plans should be established based on the characteristics of each.

1. Forest Ecosystem

Forest ecosystem reaches 65% of total areas (9,939,000 ha). Based on the composition of tree species half of the forests are coniferous (2,894 thousand ha); deciduous (1,673 thousand ha); mixed forests (1,722 thousand ha) (MOE, 1997). While coniferous pine trees are distributed over a large geographical areas, evergreen broad-leaf trees grow in the coastal areas of south and the islands, and taiga coniferous trees grow in alpine and northern regional forests.

1) Warm forests : evergreen broad-leaf forest zone

Warm forests are south of 34° in north latitude, especially coastal areas of south of 35°30' averaging over 14°C in annual temperature. A narrow coastal zone and low areas in Cheju island and southern islands are included in this zone. Some of the major species present are common camellia (*Camellia japonica*), Oak (*Quercus myrsinaefolia*), Sloumi (*Daphniphyllum macropodum*), Chestnut (*Castanopsis spp.*), Camphor tree (*Cinnamomum camphora*) as evergreen broad-leaf trees and Japanese bead tree (*Melia azedarach*) as broad-leaf deciduous trees (MOE, 1996)

2) Temperate forests : broad-leaf deciduous tree zone

Temperate forests are low areas 35°0'-45°20' in

north latitude excluding high mountains and plateaus. Average annual temperature ranges from 5-14°C. Oaks are major trees and Oriental chestnut oak (*Quercus acutissima*) in south, and Mongolian oak (*Q. mongolica*) in north are dominant. But, the distribution of oaks is well connected into areas that produce mixed species. Korean beech (*Fagus crenata*) is only present in Ulleung Island (MOE, 1996).

3) Cold forests : evergreen coniferous tree zone

Cold forest zones include plateaus in north Korea and areas in high elevation horizontally. Major species in cold forests are : Korean pine (*Pinus koraiensis*), needle fir (*Abies holophylla*), Japanese yew (*Taxus cuspidata*) that represent as evergreen coniferous tree species.

2. Freshwater Ecosystem

1) Lakes and marshes

There are only a few natural lakes and they are small in size. But studies on natural lakes are so poor that it is strongly recommended to preserve these lakes due to high in biodiversity and scientific value of habitat. Meanwhile, man-made reservoirs are numerous because they were constructed for flood control, water supply, and reservoir. Soyang, Chungju, Andong, and Daechung reservoirs are newly constructed dams leading to major changes of ecosystem. Biological survey has been conducted for 207 reservoirs over 10,000 m² in surface areas and over 10 years after construction (Lee *et al.*, 1994, MOE, 1999).

2) Streams

Stream ecosystem is extremely disturbed

because of 1) physical changes of streams (e.g., dam construction, dredging, straightening, pebble gathering, bank and crossboard development, high bank development, over-utilization of stream water for water supply), and disturbance of surrounding areas (tree harvesting, forest fire, agricultural cultivation, wetland reclamation), 2) chemical changes of streams (e.g., water pollution from factories, house sewage, toxic wastes, and oil spill), and 3) biological changes of introduced species such as bluegill, bass, giant bull frogs (Park *et al.*, 1998).

3) Estuaries

Estuarine ecosystem is degraded due to influx of nutrient basic, organic compounds, and diverse pollutants from inland. Estuaries are supposed to be high in biological diversity forming ecotone that provides various habitat for freshwater, mixed, and seawater organisms. Recently, estuarine ecosystem becomes a closed freshwater system from mixed water system due to dam and crossboard construction.

4) Other inland wetlands

In Korea it lacks lake-surrounding wetlands due to man-made lakes that cause change of surface levels. But, wetlands nearby big-river (e.g., Woopo in Nakdong river) are relatively well maintained due to the difficulties of filling in lakes. Korea became members of Ramsar Convention in March of 1997 by listing Yong wetland (Daeam mountain) and Woopo wetland as Ramsar site. But, small man-made or artificial reservoir are built in the process of dam, crossboard, and stream banks. These type of small reservoir was usually built in the lower area of

streams after a major construction of dams. In Korea there are more than 18,000 reservoirs and most of them are used for water supply to agriculture (Park *et al.*, 2001).

There is a lack of information about biological diversity despite the importance as a wetland habitat. Reservoirs near west coastal areas are important waterfowl habitat, but only Ministry of Agriculture or related organization are involved in maintaining those small reservoir. Small reservoirs also must be signified because those are located in the forests as a watershed.

Large lakes or reservoir (usually over 4km in length) are made in the upper part of streams and artificial structures (dam or crossboards). These lakes usually are exposed to algae blooming and outbreak of red algae due to increased influx of nitrogen and other organic materials. Large lakes also are managed and monitored by Korea Water Resources Cooperation, but prime goal is quantity of water not water quality thus causing troubles with other government organization that is interested in maintaining large lakes as a source of water quality (e.g., Ministry of Environment).

3. Coastal lines and marine

The three side of Korea is surrounded by sea counting 11,500 km (including islands), and east, west and south coastal lines are distinctive individually. However, east coast is steep, deep, simple in coastal lines, and directly connected to bottom of the sea due to Hamkyung and Taebaek mountains. Sandbank, sanddune, sandpond are well developed along the coastal lines that characterize special scenery.

Contrary to east south and west coastal lines are complex, and many islands are scattered around the shallow sea. Due to shallow in water depth development of tidal flat and continental shelf is distinctive. Near the shallow sea cold and warm currents are met shaping good condition for fisheries. Tidelands in Korea are well developed compared to others in the world occupying 2.8% of entire country. Eighty percent of 345,000 km² are located in the west. Despite values in biological diversity and fish production a large scale of reclamation is underway (e.g., Saemangeum Reclamation Project since 1991). A short-sighted and careless development brings habitat degradation in the west due to the loss of hatcheries and growing sites for fishes.

Coastal areas in Korea is composed of 3% with 3,074km² that occupied 10% of total land utilization. Among them 73% is distributed in West sea (2,243km²), and the rest of 27%(831km²) is developed in South, East and Cheju islands. Tidal flats are 2,393km² in which 83%(1,986km²) is situated in the West, and the rest 17% is in the South. Among regions Gyunggi and Incheon is 35.1%, Chungchungnam-do 12.7%, North Cholla 4.7%, South Cholla 44%, and Gyungnam and Pusan is 3.5%(Table 1) (Park *et al.*, 2001).

In the past marsh vegetation is widely distributed in the South and West areas, but after land

Table 1. Composition of tidal flats in South and West coastal areas

Region	Areas (km ²)	(%)
Gyungi and Incheon	840.5	35.1
Chunchongnam-do	304.2	12.7
Chollabuk-do	113.6	4.7
Chollanam-do	1054.1	44.0
Gyungsangnam-do and Pusan	82.6	3.5

reclamation majority of marshes are disappeared lacking in marsh vegetation. After independence to 1960s' land reclamation was carried out for securing agricultural paddies, but after 1970s' large scale land reclamation aimed to secure sites for factories and water resources.

4. Islands

The total number of islands in the Korean Peninsula are 3,153 composing of 464 inhabited islands and 2,689 uninhabited islands constituting relatively high in number of islands. Those are well used as habitat and breeding grounds for rare bird species such as spoonbills (*Platalea* spp), Chinese egrets (*Egretta eulophotes*) and hawks (*Falco* spp). Recently scattered islands in Gangwha County (e.g., Suk-do, Bi-do) were found to be a breeding ground for spoonbill species and Chinese egrets. Those birds breed in west coastal areas in Korea and migrated to Taiwan wetlands in winter after October (Unpublished data, 2002). Many islands are habitat for rare evergreen coniferous forests. However, systematic scientific study of island ecosystem is limited to only a few number of islands, and there will be an increased deterioration of island ecosystem due to the various development plan.

5. Ecosystem in Demilitarized Zone

The North-South borderline is 248 km that stretches from east to west coastal areas. In the East there are Baekdudaegan, and river, wetlands and plateaus whereas in the West habitat for various animals and plants. In the borderline there

are 2,800 species of flora and fauna including 146 species of endangered or protected (Byun et al, 2002). Especially Cheolwon and Hyangrobong in DMZ are important habitat for migratory birds. Yong wetland at Daeam mountain is also listed as RAMSAR site. DMZ is especially protected for many decades due to strict entrance so that they preserve primitive natural habitat and providing places that are worth monitoring (Table 2) (Ministry of Environment, 2000).

Table 2. Prominent natural habitat for various natural resources around Demilitarized Zone

Region	Ecosystem status
Woongjin county	<ul style="list-style-type: none"> • sand dunes, golden rain tree, Pacific harbor seal • White-tailed sea-eagle and natural monument • summer habitat for Chinese egret, spoonbills
Gangwha county	<ul style="list-style-type: none"> • mullet goby and rare fishes • rare species habitat, hawk breeding
Gimpo country	<ul style="list-style-type: none"> • wetlands for wintering birds • prominent plant species
Paju city	<ul style="list-style-type: none"> • wintering habitat for migratory birds
Yunchun county	<ul style="list-style-type: none"> • Korean bittering and other rare fishes • endemic fish species • rare wetland habitat for birds • forest vegetation
Cheolwon county	<ul style="list-style-type: none"> • endemic fish species • wintering habitat for crane species • wetlands (natural monument) • Chinese minnow and deer • forest birds
Yanggu county	<ul style="list-style-type: none"> • Mt. goat and flying squirrel • Manchurian trout • rare birds and butterflies
Gosung county	<ul style="list-style-type: none"> • prominent valleys and virgin forests • rare forest birds • southern limit for black star minnow; salmon • Whooper and Mute swan
etc	<ul style="list-style-type: none"> • Han and Imjin river • wintering habitat for crane species

III. Conservation Strategies for Major Ecosystem

Natural ecosystem, recently is so fragmented in the process of industrialization and urbanization conservation and restoration should be focused on connectivity to maintain endemic biological diversity.

1. Forest ecosystem

Conservation of forests should be enforced as a major source of biological diversity. Conservation of forest ecosystem should also be served as an umbrella for biological species. Five major mountain ranges are the backbone of the country, and often called as 'Baekdudaegan' and the forests are a major source of biological organisms. Most national and public parks are located around five major mountain ranges that constitute important habitat for biological organisms especially large-sized carnivores (Mattson and Reid, 1991). These areas also act as the essential part of 'Green Networking' to provide genetic resources and species diversity. Restoration of forest areas will minimize natural and artificial

catastrophe by connecting the surrounding natural environment. Green-networking is proposed to connect mountains, streams, seas, urban and rural areas and integrate management as one unit. There are three steps to manage 'Green Networking'(Table 3) (Park *et al.*, 2001, MOE, 2000).

The management goal for the National Park should be to protect natural ecosystem and scenery, to promote sustainable development, and to promote public health and recreation. This can also be achieved by providing sites for research and development as well as education place for the public and researchers. In National Park new goals must be set up and local development should manage National Parks for nature conservation and sustainable development(Park *et al.*, 2001). 1) From development to conservation, 2) From visitors' interests to natural resources management, 3) From recreation to education grounds for nature, 4) Special management in accordance with each own characteristics - Nature ecosystem conservation(e.g., Mt. Seolak), Nature scenery(e.g., Mt. Bukhan, Hanrye Marine Park), Historical monument(e.g., Gyungju).

2. Inland water ecosystem

Streams and rivers that are directly connected with various environment are the essential part of living space for aquatic vegetation and animals. The surrounding of wetlands and freshwater vegetation works as major habitat for living organisms that function as ecological corridor. River and streams are the eco-bridge that connects mountains with cities, agricultural fields, and sea. Conservation of freshwater ecosystem

Table 3. Basic concept of 'Green Networking'. Green Networking is composed of three parts based on the importance of ecosystem and its diversity.

Categories	Contents
Core area	Baekdudaegan, National Parks, Four major rivers, West and South coastal areas, Demilitarized Zone
Eco-corridor	Essential ecosystem and adjacent areas into one unit with ecological corridor
Restoration area	Unplanned regions, polluted areas and habitat in need of ecological recovery

should be (MOE, 1997) : 1) to avoid straightening, concrete, culvert of river and streams, 2) to minimize an influx of organic, inorganic pollutants, 3) to build environmentally friendly streams by restoration of damaged streams (MOE, 2000), and 4) to minimize introduced species (e.g., bass, bluegill, and bull frogs) for endemic stream ecosystem. Deterioration and destruction of freshwater ecosystem are contributed to the most significant factors (35%, 15/43 endangered species) in type of threats that lead animals and plants endangered (Lee *et al.*, 1998).

3. Coastal and marine ecosystem

Coastal areas are fish habitat for hatching and breeding, and should secure as areas for production of marine biological resources that directly connect sea with estuary. Recently, over-harvesting of marine biological resources, frequent outbreak of red-tide, oil spillage by ship wreckage, and influx of polluted matter from inland are threatening biological diversity in marine ecosystem. The tidal flat in the west is one of the five best in the world (Baltic sea in Europe, east coast in Canada, Georgia coastal lines in USA, Amazon estuary in South America). Plans for large scale reclamation project in Saemangeum must be reconsidered and restoration plan should be enforced. Fortunately the Wetlands Conservation Act by Ministry of Maritime Affairs and Fisheries was ratified on Feb 8th, 1999. This act enables the designation of important wetland areas for the following objectives (Lee, 2000) : 1) the maintenance of the natural sites, 2) the maintenance of a special biodiversity, 3) the conservation of threat-

ened species(plants and animals), 4) the protection of exceptional scenery, 5) the conservation of special geological and morphological features. But sites have not been designated as yet.

Furthermore Environmental Impact Assessment is applied as a major tool for conserving wetlands. However, Public Water-surface Reclamation Act asks a environmental and damage impact statement within 6 month-1 year after permission. This can be longer because of monitoring and assessment. At the same time the purpose of land reclamation is changeable every 5 years that makes very difficult to monitor after construction. Unlike construction project in lands there is a limited participation from community and local residents in a policy making process when in wetland development.

4. Island ecosystem

Unlike inland ecosystem island ecosystem is relatively stable and forms distinctive biota and ecosystem that resulted from long independent evolution. This situation leads to home for rare and endangered animals and plants, thus being highly worth preservation. Nonetheless, there lacks in information, and without comprehensive management island ecosystem is heavily destroyed due to the exploitation of stone collection, plants in the pot, unplanned grazing and introduction of terrestrial animals, and development pressure. Conservation plan, therefore should be based on the comprehensive survey and data collection of fauna and flora. Based on the scientific survey designation of protected areas should be followed. Since most islands are attractive in sightseeing courses and program for

eco-tourism and recreation should be developed. This will eventually help preservation of local biological resources by securing local residents with economic profit. Among 3,153 islands except for the Korean peninsula there are 464 inhabited islands whereas 2,689 uninhabited islands. Majority of islands maintain its unique natural ecosystem. Twelve islands were selected as Natural Monument. Forty-eight islands including Dok-do were designated as 'Special Islands' based on the new Act 'Special Law for Ecosystem Conservation including Dok-do and other Islands' by Ministry of Environment.

5. Demilitarized Zone ecosystem in Cheolwon areas

Cheolwon is best known as a wintering migration site for crane species - red-crowned crane (*Grus japonensis*), white-naped crane (*G. vipio*), hooded crane (*G. monacha*) and common crane (*G. grus*). Cranes make biannual migrations during which they use wetland, grassland, or agricultural areas as stopover sites (Archibald *et al.*, 1981). Crane species in East Asia many of which are endangered, migrate between south-eastern Russia and northern China to central China and Japan. Demilitarized Zone in Korea is a stopover for a crane migration both autumn and spring.

Cheolwon, located 75km north-northeast of Seoul is a wide basin spanning the DMZ. It was abandoned by people at the end of the Korean War and reverted to grasslands and marshes during that time. It was discovered to be a wintering site for white-naped and red-crowned cranes in the 1970s, but it was reclaimed for agri-

culture in the 1980s.

The red-crowned crane of east Asia is listed as an endangered species (Lee *et al.*, 1998). It is closely associated with wetlands, which are being converted for agricultural use at a rapid rate throughout Asia. Red-crowned cranes breed only in north-east Asia, where they have two separate populations. Red-crowned cranes migrate from two breeding sites in continental Asia during their autumn migrations. It was revealed the timing of their movements and the exact locations of stopover sites by satellites.

The daily movements by cranes on wintering grounds of the eastern route clarify a land use pattern only at Cheolwon (38°18' to 38°37'N, 127°40' to 127°42'E). The site can be divided into two sections. The DMZ and the CCZ (Civilian Control Zone). The DMZ is off-limits to regular human activities, while the CCZ is a buffer zone which is used only for agriculture and military installations. Additionally there is a difference in habitat types. The DMZ is an area of low hills and meadows with natural vegetation, and ice-free stream due to the presence of hot springs. The CCZ is a developed area of irrigated agricultural fields. Among DMZ cranes showed daily movement pattern in CCZ and night movement in DMZ (Higuchi *et al.*, 1996).

The potential reunification of DPRK and ROK will open the possibility to swift development. In preparation for reunification the Korea Research Institute for Human Settlement (KRIHS) has proposed a plan for increasing infrastructure, water resources, and economic growth in ten ROK counties including Cheolwon that border the DMZ. A road through the Cheolwon basin is already under construction, and its impact on the

cranes has been unmitigated.

Currently Ministry of Environment and other related environmental organization are launching the designation of UNESCO TBR (Transboundary Biosphere Reserve). The habitat will be categorized into four groups. Transboundary Support Act(2000) was activated stating that government will support necessities to transboundary region for economic development and welfare for residents, systematic preservation of natural environment, and foundation of peace unification. Experts are expecting that transboundary will face an increased infrastructure such as roads, railways, and other facilities for transportation, education including major national universities, factories, sports and other recreational purposes. These development projects will allow depredation of wetland and forests resulted in the loss of ecosystem in transboundary.

IV. Concluding remarks

Biodiversity management is characterized in generalization and integration as well as ecological processes. There are five major conservation strategies for conserving and managing biological diversity. 1) To assess and make inventory biological diversity in Korea, 2) To continuously monitor biological species, genetic resources, ecosystem that previously revealed, 3) To identify a major threat to valuable habitat and ecosystem (e.g., environmental pollution, introduced species, GMOs, etc) and protect them from the major threat to secure biological species and habitat such as in-situ and ex-situ conservation, 4) To restore damaged habitat. When restoring endemic species must be sought to recover damaged

areas. In that sense one has to identify endemic species (especially plant species) regionally and apply only listed endemic vegetation when restoring damaged areas. 5) To accumulate funding to save important habitat, e.g. transboundary. Based on our experiences in previous economic development during 1960-80s residents and local people usually are against designation of natural reserve or preservation. In this regard we should compensate the economic loss to local residents whose properties will be limited.

In Korea the diversity in ecosystem level is so diverse that systematic ways should be sought. The 'ecosystem approach' is a method of sustaining and rehabilitating natural systems as well as its functions and value (Anderson, 1991). Ecosystem approaches integrate ecological, economical, social factors. This approach is mainly applicable to the range of a local border defined as an ecological boundary. The goal of this approach is to maintain and to sustain healthiness of ecosystem, productivity, biodiversity, and quality of life. This goal can be accomplished through a method to approach a natural resource management which is fully integrated with social and economic goals. Recently one must understand that conservation of large areas needs a help from both local government and communities.

We also need to clarify the areas in accordance with natural ecosystem. Currently various protected areas are not so clear that we need to categorize these areas. For example the National Park in Korea is overly duplicated into many regulation and laws. Ambiguous designation of excellent natural ecosystem makes unclear management and causes a conflict among related government organizations (Table 4). This will cause

Table 4. Duplicate designation of management for Excellent Natural Ecosystem under different legal protection

Categories		Total	Nakdong estuary	Mujechi wetlands	Yong wetland	Woopo wetland	Mt. Seolak	Mt. Chri	Mt. Halla	Hong island	Dok island	Mt. Hyungji	Bam islnad, Han river
Natural eco-system	MoE*	5	×	×	×	×		×					
	Cities and	6										×	×
	Special laws	1								×			
Parks	Province												
	National Park Province Park	20 29					×	×	×	×		×	
Nature protected areas		4			×		×		×	×			
Biosphere		1					×						
Virgin Forests		145					×	×		×		×	
Bird Sanctuary		741					×	×		×			
Wetland	MoE	4	×	×	×	×							
Protection	IUCN	21	×			×							×
	Ramsar	2			×	×							
Etc	Coastal areas special management	-	×										
	Natural monument	-	×								×		

*MoE = Ministry of Environment

different type of management to similar resources. Furthermore the same natural ecosystem are designated and managed with different regulation and laws(Yoon *et al.*, 2000, Park *et al.*, 2001).

To achieve biodiversity conservation in ecosystem level the following measures should be sought and developed (Rees, 1990) : 1) Stimulate incentive measures, 2) Enhance abilities in research, education and advertising, 3) Exchange information and technology, 4) Promote international cooperation, and 5) Secure funding for saving important habitat.

Ecosystem conservation must seek ways to secure renewable natural resources. As indicated by WCED (World Commission on Environmental Development, 1987) a sustainable development is 'to promote the welfare of present generation

without degrading quality of life for future generation.' We have to bear in mind that proper management and utilization of nature resources should be for future generation.

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