

Chapter 2

Landscape Ecology of the DMZ Area

2.1 Introduction

This chapter encompasses the landscape ecological point of view of the DMZ. In the first part of this chapter, the concepts, scientific theories, principles, and models in the characterization of the ecological landscapes are presented. Moreover, in the latter parts of this chapter, the results of analysis and evaluation of expert investigation follow.

2.2 Landscape Ecological Approach

2.2.1 *Landscape Ecology at Regional Scale*

In every region on Earth and at every stage in history, human survival has required a basic understanding of landscapes. In contemporary ecology, a landscape is a heterogeneous area consisting of distinctive patches, which landscape ecologists refer to as landscape elements organized into a mosaic-like pattern. The elements of a mountain landscape may include forests, meadows, bogs, and streams, while those in urban landscape include parks, industrial districts, and residential areas (Molles Jr. 2010). Landscape Ecology is defined as the study of the relationship between spatial pattern and ecological process over a range of scales.

2.2.1.1 Concepts of Landscape Ecology

Earl N. Troll (1939), a geologist, coined the term ‘Landscape Ecology’ at the time he was studying the issues in land development and use in Eastern Africa. As he was taking aerial photographs and consequently analyzing the landscapes, he found out that there is an intimate connectivity between geology and ecology and declared landscape ecology as “Ecoscience”, distinguishing it from geoscience.

Landscape ecology is a science which explains the phenomenon of composite interaction under comprehensive and certain rules existing between life community and its surrounding environmental conditions. This science has been developing and is based on the existing geology and ecology since 1960s up to date.

Ecology is a study which explains vertical relations arising between water, wind, energy flow, animals, and plants. Landscape ecology is a horizontal study which explains phenomenon arising between spaces. Serious attention has been given to planning and designing areas, specifically focusing on the phenomenon arising between geographic spaces (Landscape) considering the existing ecological characteristics which evolved in these spaces. As a result, landscape ecology can be briefly defined as ecology objecting to landscapes. However, the important matter is the fact that landscape ecology studies prioritize the special distributions and how these develop in specific landscapes and, emphasize the role of disturbances, including human influences in the subject area.

2.2.1.2 Objectives of Landscape Ecology

Landscape ecology intensively studies the structures, functions, and changes of landscapes. The specific tool employed by researchers is the geographical information system (GIS). Data from terrestrial and aerial photographs including satellite imagery are also pertinent to the assessment and evaluation. These studies concentrate on the planning process utilizing all the gathered information.

Landscape ecology is classified into four kinds: (1) patches, (2) edges and boundaries, (3) corridors and connectivity, and (4) mosaics: Pattern and scale.

Wherefore, landscape ecology data encompass specific variables in describing, analyzing, and measuring patches, edges, boundaries, corridors, and mosaics. It is quantified according to metrics, connectivity, pattern and scale of the distribution, and migration of life species. These studies significantly contributed to the development of landscape ecological models and methods regarding migration of life species within mosaics, diversification of life species in patches, and corridors. In case of plants, landscape ecology determines the elements, moisture, soil, nutrition, and identification of primary species thriving in the landscape under the study's interest. The characteristics based on landscape ecology are described in Table 2.1. On the other hand, Table 2.2 shows Forman's patch types.

Meanwhile, principles of landscape ecology are more concretely suggested as:

First, sizes and forms of patches are ecologically suggestive of its status in terms of productivity, diversity of species, soils, and waters.

Second, habitats decide the size of patches. A patch is a wide area which is relatively homogenous but different from surroundings considering the inhabited radius of major life species.

Third, natural vegetation in wide patches are necessary in order to preserve and protect aquifers that ensure the quality of lake water.

Fourth, several wide patches should be needed to preserve life diversification of ecosystem (pine trees patches in different size, vine yard patches, and so on).

Table 2.1 Characteristics based on landscape ecology

Elements	Characteristics based on landscape ecology
Patches	<ul style="list-style-type: none"> • Distinguished and analyzed in the size, numbers, and location's point of views • Size of patches: Core parts' habitats and species, internal habitats and species, areal extinction possibility, distinctions, diversification of habitats, barrier against disturbance, large-scale patches, and small-scale patches • Number of patches: loss of habitats, activities of distorted entities, number of large-scale patches, number of small-scale patches, and collectivized patches into habitats • Locations of patches: extinction, selection of patches for preservation
Edges and boundaries	<ul style="list-style-type: none"> • Importance of edges becomes lots of opportunities in order to consider ecological succession • Structure of edges: diversification, width, ecological boundaries, edges as filtering device, and slopes • Boundaries (lineal or curve type): natural and artificial Edges, lineal and curve types of boundaries, rough boundaries and smooth boundaries, curve degree and width of edges, tail, and spur • Types of patches: edges and internal species, interactions on surrounding environments, ecologically optimized types of patches, features, and directions
Corridors and connectivity	<ul style="list-style-type: none"> • Habitats' networks • Species' corridor: control of corridor function, GAP's effectiveness in corridors, and structural similarity versus plant's similarity • Stepping stone: connectivity, distance, loss, and concentration • Road and baffle wall: roads and corridors, wind erosion and its control • Stream corridors and dissolved substances, widths of stream corridors in the main streams, widths of stream corridors, and connectivity of stream corridors
Mosaics: pattern and scale	<ul style="list-style-type: none"> • Segregation of habitats due to transformation of land use occurred by human activities • It itself can emphasizes functions of landscapes • Networks: connectivity and circularity of networks, circulation and other alternatives, density of species and size of nets inside of corridors, effects of cross-points, species in the connected small patches, distribution of species, and small connected patches • Types of fragmentation: Internal versus entire loss of habitats, fragmented patches, suburbanization, and protection areas for foreign species • Barometer: the lowest scale of mosaic, identification of barometers for animal fragmentation, special species, and general species, types of mosaics for multiple habitats

Fifth, Islands close to continents preserve more species than isolated islands far from continents. Likewise, wetlands close to forests preserve more species than wetlands distant from them.

Sixth, corridors should be made wider than 60–90 m before it becomes a “Disturbance Patch” for birds roaming in open farm areas according to a study regarding electric pole corridors in temperate deciduous forests.

Table 2.2 Forman’s patch types

Disturbance patch	Recently created by some form of disturbance, e.g., forest fire
Regenerated patch	Patch recovering from disturbance, e.g., forest clearance in the process of regrowth
Environmental patch	Some sharp discontinuity, e.g., change in soil type that cause a distinct change in the plant community
Remnant patch	Area remaining of the original habitat isolates by an encroaching matrix, e.g., Woodland patch amongst agricultural fields
Introduced patch	A habitat created by human activity, e.g., a Woodland clearance

Seventh, encountering points of waterways should be accounted for large vegetated nodes of large-scale vegetation.

Eighth, form of patches should be curve and irregular.

Ninth, mosaics should be made of combining patches, corridors, and metrics by arranging the principles of land use through synthesizing.

In the landscape ecological point of view, the analysis of present conditions is based on the four kinds of landscape ecological principles (edges and boundaries, corridors and connectivity, mosaics, pattern and scale). This analytical method is used in the planning of the restoration of streams and landscapes. A data-based restoration plan and environmentally friendly land use plan influence successful evaluations. Simple methods of qualifying the ecological properties of a landscape are shown in Fig. 2.2. Figure 2.1 shows the patch work of traditional DMZ agriculture in terms of land use.

2.2.2 Bioregional Approach Model

Bioregional approach is an approach based on plan, preservation, and development. It is an approach combining each unit of analyzed landscape setting high



Fig. 2.1 The patch work of traditional DMZ agriculture

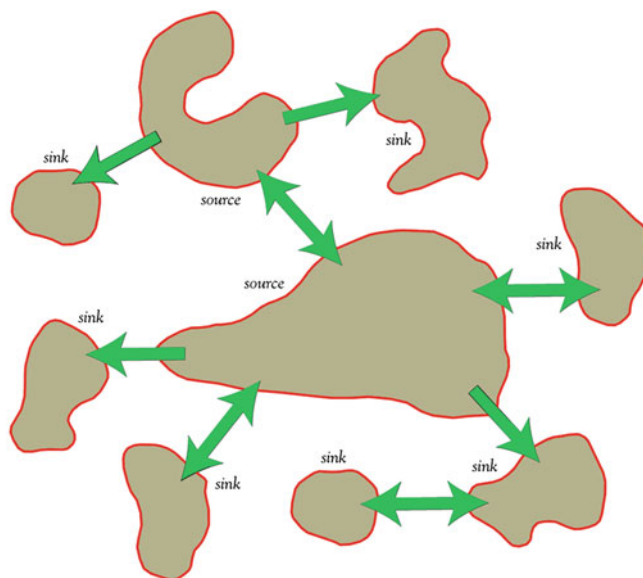


Fig. 2.2 Simple methods of quantifying the ecological properties of a landscape. Landscape Physiognomy is the physical layout of an ecosystem in the landscape. The habitats of interest are the ponds and two measures are indicated here namely; the length of the boundary (*red*) of each patch and the distance between pairs of patches (*green*)

values on continuity of landscapes apart from the exiting method which divides dissected parts of landscapes (Jones and Jones and SNU 1998). This is for establishing place unit as a basic unit based on geographical characteristics in areas and analyzing landscape resources through examining ecological elements (natural, cultural resources) which compose specific characteristics in the each area (UNDP 2000). That is, units of bioregional areas are in the most significant level and are divided as landscape district in lower significant levels and, place unit in the lowest significant level. Table 2.3 arranged the contents of the concepts and features regarding life bioregion, landscape district, and place unit using the bioregional approach. Characteristics of bioregional approach can be found in the course of this process as its striking feature. Each classified place unit is to establish a management plan targeting areas by combining them to a bigger area (e.g., targeting these areas by combining landscape district, subregion, and bioregion) of homogenous units after the evaluation process.

Table 2.4 suggests the contents according to each level as it undergoes the process to establish preservation plans of landscape resources through the bioregional areas. Featured contents in this process can be mentioned as second and third steps. In the second step, characteristics of geological areas are stipulated according to physical elements, such as water system and land form (biological characteristics) and the fundamental resources that compose the characteristics of these areas. In the third step, characteristics and features of each area are stipulated

Table 2.3 Concepts and characteristics of bioregion, landscape district and place unit

Bioregion	<ul style="list-style-type: none"> • Bioregional area, the largest unit of approaching unit • Classification by distinctive climate in areas, Landform, vegetation, river basin, and types of land use (in classification, a process was made through to boundaries and features recognized by area residents through contact and participation of area residents) • Concepts of evaluation of preservation values, plan, and management are provided in landscapes of object areas
Landscape district	<ul style="list-style-type: none"> • Lower unit in Bioregion • Classified by waters and mountains and range to recognize observers • There are many cases where area residents have intimate names on the areas and it is often recognized as specific region • Primarily classified focusing on landform, animal/plant habitat conditions, waters, land use patterns and additionally classified by adding culture, and life styles through site visitation
Place unit	<ul style="list-style-type: none"> • It is lower unit of landscape district and the lowest unit in area classification of bioregion areas • “Surrounding Space” as unique visual featured river basin • Possible to immediate visual distinction • Decision by vegetation, landform (Landform), ridge (Ridge) in boundaries

as the area's map sectioned by life species' area and divided into place units. The mapping is based on the observation made from photographs of each sectional area and the testimonies of area residents. The relation between the resources of each area composing the landscape to that of each place unit will be better observed in the bioregional approach. This reveals the natural, cultural essence, and the process in the bigger bioregional position (macroscopic point of view).

However, the most important matter is the comprehension of values and attitudes of the people living in the area through site visitation. That is, classification by physical aspects should be simultaneously performed along with the consideration of the cognition of the residents, and the classification of predetermined spaces.

As this area classification is performed, consideration includes the academic, social, and physical aspects of the area. The classification, therefore, should necessarily be based on sufficient basic knowledge, data review, and field experiences to be precise in the classification.

2.3 The Application

2.3.1 Classification of DMZ Ecosystem

The bioregion of the DMZ ecosystem can be classified into the following: the Western (Paju bioregion area), Central (Cheorwon bioregion area), and the Eastern (Goseong bioregion area). This is shown in Fig. 2.3.

Table 2.4 Process of bioregional area approach

Steps	Contents
First step project preparation	<ul style="list-style-type: none">• Development of organization and targets in the task (composition of performing group, unofficial discussion on landscapes, development of targets)• Object areas (selection of candidate areas for the study)• Comprehension on data (decision of necessary information, decision of information process method)• Process plan and schedule (decision of process method between work group, adjustment of work period)
Second step understanding of landscape of target area	<ul style="list-style-type: none">• Mapping process of bioregion (natural area in candidate areas and regulations and mapping process of bioregion)• Mapping process of Landscape district(Landscape District) (Bioregional Division into landscape, utilization of natural Boundaries, such as water system)• Mapping process of place unit(Place Unit) (division of landscape districts into place units, title imposition including areal feature)• Recording of characteristics and documentation for concerning matters of the community (deduction of concerning matter through discussions with area residents, photographing on major areas showing features of place unit)
Third step identification of essential resources	<ul style="list-style-type: none">• Review and modification of landscape district, place unit boundaries, and names• Final mapping process and examination of resources (actualization of essential resources through collective description on objects and features and drawing of the final map)
Fourth step determination of landscape quality	<ul style="list-style-type: none">• Development of evaluation standard and ratio (selection of landscape quality and determination of ratio)• Evaluation of place unit (Application of standards to essential resources in each place unit)• Combination with preference results (combination of other evaluation methods and preference study deducted as results)• Analysis of the entire results (determination of each Landscape district and landscape quality per unit)• Composition of the final report
Fifth step development of implementation plan	<ul style="list-style-type: none">• Preservation of areas' landscape resources and establishment of preservation plan

The identifiable composition of the species in the areas is the diversified characteristics of ever green needle-leaf trees, the broadleaf trees, and bamboos.

The Korean Peninsula is divided into eight plant geographical regions namely: (1) northern high mountain area, (2) northern and southern high mountain area, (3) central mountain area, (4) southern mountain area, (5) central and western island area, (6) southern island area, (7) West Sea, South Sea, and East Sea island area and relating inland area, and (8) segregation area between South and North.

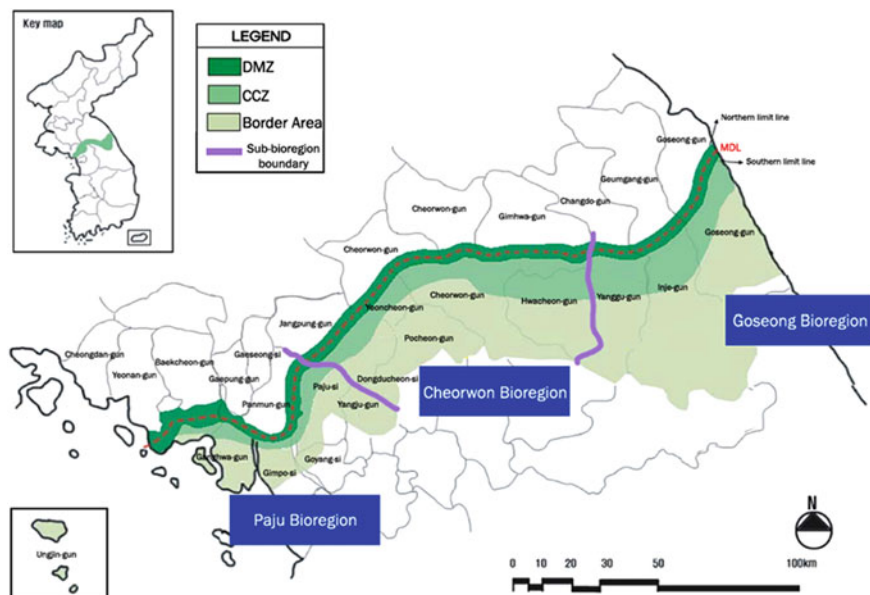


Fig. 2.3 Classification of DMZ ecosystem biogeography

In this book, characteristics are analyzed per each regional area and divided into west, central, and eastern region, specifically considering the plant geological classification, current diversification, and water system networks in the DMZ.

As the characteristics per bioregions are examined, the Goseong area maintains a generally excellent life species in its forest ecosystem, forest wetland, and coastal ecosystem. In the case of the Cheorwon bioregion area, it became the wintering area of the world's rare birds due to the existence of farmlands and inland wetlands. The Cheorwon plain, on the other hand, is widely spread with many developed reservoirs such as the Sanmyung Lake, Togyo Reservoir, Hak Reservoir, and among other smaller reservoirs. There are also naturally formed swamps in the Cheorwon-like Saemtong and the abandoned paddy field are also well-developed marshes. Lastly, the Paju Bioregion area shows high diversification of life species and well-developed wetlands and mud flats that help prevent soil erosion and floods.

There are specific areas in the bioregions that display significant biosystems. The Hyangrobong area (part of the Goseong bioregion area) preserves an ecosystem close to pristine forest, with very diversified plants and serves as the connecting axis that links to Mt. Kumkang and Mt. Seorak. The only high peatland in Korea is located on the top of Dream Mountain and designated as wetland protection area by the Ramsar Convention and the Ministry of Environment.

Hwajinpo Lake, located nearby East Sea area, is also highly evaluated as a leading wetland with sea water flows. The Dutayeon area is also known as the best habitat for lenok in South Korea. In the Cheorwon plain, rare birds such as the

Grus japonensis and the white-naped crane (among other types of rare cranes) spend their winter in its wetlands.

The Imjin river estuary of Paju Bioregion area, there are specific world rare birds that frequently inhabit in the area namely; the blackfaced spoonbills and the *Grus japonensis*. In the Sacheon river basin, near Panmunjeom area, blackfaced spoonbills are also observed to inhabit there. In these rivers, a rare fish called *Mugilogobius Abei* is also seen thriving here.

Various life species are observed in Eoryong Reservoir and Daeseong Reservoir, such as rare fish, reptiles, and amphibians besides the birds and animals mentioned earlier to have inhabited there.

2.3.2 Pattern Classification of DMZ Based on Forman's Pattern Classification

This section expands the discussion on the ecological pattern analysis method applied to DMZ previously mentioned in the preceding sections. This method is the Forman's Pattern Classification and applied to the following major areas of the DMZ.

Estuary of the Han River Area

As the whole sections of Han river flow through Gangwon province, Chungcheongbuk province, Gyeonggi province, and Seoul city, only part of estuary of the Han river, of which flows into Yellow Sea among sections of the entire 281.7 km stream, is accounted for DMZ and CCZ. The estuary of the Han river has plain form due to characteristics of landform in Korean Peninsular and shows a form of mud flat as a form of estuarine wetland.

Figure 2.4 shows an image of the estuary of the Han river with wetland or meadow wetland form in most sections. It is not an area with evident mountains or developed trees and does not show figures of noticeable patches except for corridors due to roads or waterways. This area, like other DMZ and CCZ, also shows disconnection between habitats and ecosystem due to cease-fire line. This is not desirable in the landscape ecological point of view but is rather an irony in a sense that the present natural environment has been preserved.



Fig. 2.4 Landscape ecological pattern analysis on the estuary of the Han river



Fig. 2.5 Landscape ecological pattern of surrounding farmlands in the Imjin river, Paju

Paju Imjin River Area

Figure 2.5 shows an image of the surrounding areas of the Imjin river that flows through Paju area, Gyeonggi province. Presently, this area belongs to CCZ and it shows an area with widely developed wetlands along with the Imjin river. But cultivated areas into rice paddies appear in all over the places for the purpose of residents living in CCZ.

This area is in nature composed of Woodland patch and surrounding forests encircling farmlands which can be considered to be area's mosaics. The main stream of the Imjin river and its tributary which flows from the Imjin river become corridors, and it is divided into patches in wetland areas, patches in farmland areas, and patches in grassland areas centered as tributary of the Imjin river. The cease-fire line passes through between farmland areas and the Imjin river. Yet, habitats appear to be satisfactory in overall landscape ecological point of views, even though it shows forms of habitats' disconnections in part as farmlands are located in the center of the area.



Fig. 2.6 Landscape ecological pattern near the Imjin river, Paju

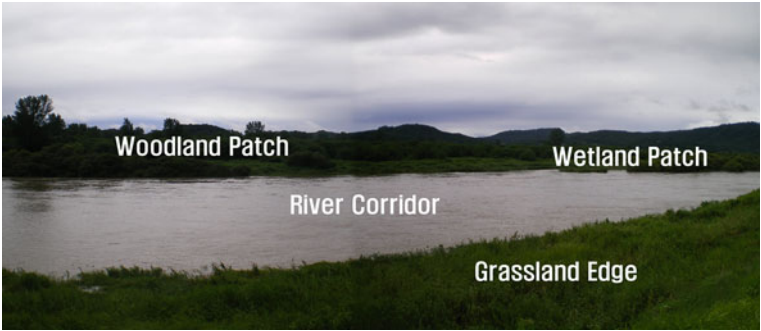


Fig. 2.7 Landscape ecological pattern of Chopyeong island, Paju

The area shown in the Fig. 2.6 is also a place near stream of the Imjin river, Paju and this place can be considered to be the representative image of habitats' segregation due to political reason which DMZ and CCZ have in the country. Well-developed wetlands along with the Imjin river show figures of habitats' fragmentation with the cease-fire line as boundaries. Habitat fragmentation is considered to cause serious problems in DMZ and CCZ due to the cease-fire line according to landscape ecological point of view, considering sections of DMZ and CCZ that are composed of soils without vegetation due to the establishment of the cease-fire line.

The area composing Woodland patches in Fig. 2.7 is an island area called Chopyeong island located in the Imjin river. It is natural area with no human residence and where a village called Chopyeong Dong once existed and currently human access is controlled due to security issues.

The center area of Paju Chopyeong island area shows the regenerated Woodland patches, such as *Morusalba*, *Populus deltoides*, and surrounding shows wetland patches, such as *Salix koreensis* Andersson, *Phragmites australis*. The Imjin river flows between vicinity inland area and the Chopyeong island, and the surroundings of the Imjin river show grassland edges.

The area in Fig. 2.8 is called Jangdan peninsular. The Imjin river flows from the east to the south and joins with Munsan river in the Southeastern direction. It is used to be wetland area with developed *Phragmite saustralis* community in the past, but presently many areas are cultivated as farmlands. In the partially



Fig. 2.8 Landscape ecological pattern of Jangdan peninsula, Paju

access control area, *Phragmites japonica* Steud community or *Miscanthus sacchariflorus* Benth communities are developed. Water flow gate is blocked between the Imjin river and Jangdan peninsula due to the bank constructed there.

Most of Jangdan peninsula wetland area is rice paddy matrix and wetland patch is located in the center. Stream corridor flows in the middle, which connects rice paddies and the wetland. But habitats in Jangdan peninsula wetland are disconnected as a bank is constructed between rice paddies and the Imjin river. Woodland patch (Woodland Patch) and the Imjin river (River Corridor) are located in these surroundings.

The Imjin river, often quoted as “expressing sorrows of division”, as it flows through South and North, has many existing cultural heritages along with the river surroundings and it is one of the interesting focuses in DMZ and CCZ due to its clear waters and beautiful sceneries. As the stream, shown in Fig. 2.9, is also in the area, especially in the first area where the Imjin river flows into the South and a bridge called Pilseung bridge exists.

One side is composed of Woodland patch and the other side has developed flood plain wetlands and centered by the mainstream of the Imjin river. One side also has the cease-fire line and it is a cause of habitats’ fragmentation. It functions as a Road Corridor since migration along the cease-fire line is possible. However, this area also preserves beautiful sceneries as well as very clean natural environments due to fragmentation from the outside for a long time, and therefore patches have not occurred due to the fragmentation.

Sacheon River Area

Sacheon, Paju area, was originally farmland area but it became an abandoned paddy field as human access has been impossible. At the present time, it is being changed into a feature of wetlands. Therefore, the wetland area is the matrix of this area and the Woodland patch is located in the center of the wetland. The forest axis of the Dora Mountain and Baekhak Mountain connected along with DMZ area is a Corridor Area.



Fig. 2.9 Landscape ecological pattern of Pilseung bridge area in the estuary of the Imjin river, Yeonchoen

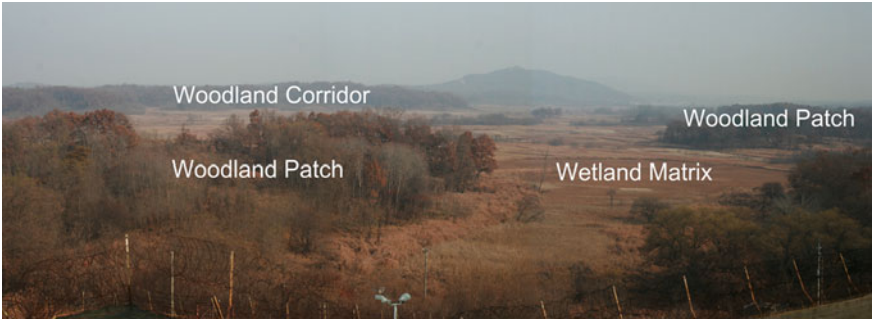


Fig. 2.10 Landscape ecological pattern on surroundings of Sacheon river, Paju

The area shown in Fig. 2.10 is the rear wetland area of Sacheon stream in DMZ near Sagok Li area, Paju Gyeonggi province. It is changing into a natural wetland since human access is prohibited. Woodland patches are located in some places as well. It becomes a good habitat for wild animals and plants since wetland habitats and forest habitats are located in one area.

In the rear wetland area of Sachoen stream located near Dora Mountain Station, beautiful sceneries are shown as human access have not been possible. Therefore, the wetland area is the matrix of this area and the Woodland patches are also located in the center of the wetland. The forest axis of the Deongmul Mountain connected along with northern DMZ area to the Sacheon stream which flows along with DMZ is a Corridor (Fig. 2.11).

Figure 2.12 shows the image of Gyeonggi Rail Road in Paju, where the road ran across the dimensions of the formed patches and habitats' disconnection is inevitable in the left side. The reservoir located in the center forms a patch which functions as a wetland with a reservoir in the center. Forests are shown as forms of patches not as consecutive forest patches and new types of patches are shown as meadow wetland which appears between the wetland and the forest. In this area, ecological bridges can be considered in order to link the disconnected habitats. The



Fig. 2.11 Landscape ecological pattern on surroundings of the Dora Mountain station



Fig. 2.12 Landscape ecological pattern on surroundings of Gyeonggi rail road, Paju



Fig. 2.13 Landscape ecological pattern on the reservoir in Daeseong-dong area, Paju

habitats' disconnection poses as the most serious problem in the conservation efforts.

This area is a village situated in the Daeseong-dong area (Paju city, Gyeonggi province) of the DMZ and is the only area of the DMZ where human reside. This area shows typical farmland scenery patterns with simultaneous appearance of paddy patches, lake patches, and Woodland patches, since most of the residents are farmers. Farmlands and forests are distributed and the Daeseong reservoir provides the water needed for agriculture. Daeseong reservoir also provides water to the habitats where migratory birds and wild animals dwell. The area is shown in Fig. 2.13.

Paju Sewol Stream Area

This area cannot be seen in general maps and topographic maps in the country but can be seen in military maps. As shown in Fig. 2.14, the Paju Sewol stream area is entirely forest based, but patches are formed as roads pass through the forest. Stream corridors are formed in this area along where the Sewol stream flows.



Fig. 2.14 Landscape ecological pattern of Sewol stream area, Paju

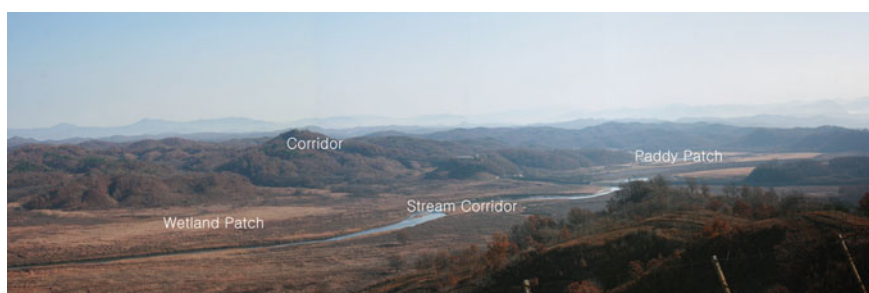


Fig. 2.15 Landscape ecological pattern in Sami stream area, Yeoncheon

Wetland is not widely developed since the stream is not large enough to form as patch. It only formed an edge wetland. The forest matrix is disconnected by roads that branched out up to the rear portion of the Paju Sewol stream area. In the rear portion, there are wide spaces of wetlands and formed as patches as shown in Fig. 2.14.

Yeoncheon Sami Stream Area

Figure 2.15 shows the Sami stream in the Yeoncheon county of Gyeonggi province, which emanates from the Sami river basin. This stream naturally curves across the dimensions of the area and the wetland surrounding it propagated a very well-developed *Phragmites australis* community. The forest ecosystem observed near the Sami stream enjoins with the stream ecosystem and the wetland ecosystem. Thus, it is a salient need to preserve this area and management efforts should be geared toward protecting it from threatening elements. This area did not show human-related damage as evidenced by the absence of disconnected habitats. The stream forms corridors of wildlife animals and the forest acts like a natural Ridge that encircles it. Wide and small-scale wetlands patches appear in this area influenced by the flow of the Sami stream but, in general, the various landscape ecological patterns are not yet established.



Fig. 2.16 Landscape ecological pattern of Sami stream river basin



Fig. 2.17 Landscape ecological pattern in wetland area in the rear part of Sami stream

Figure 2.16 presents the Sami stream river basin. The picture does not succinctly illustrate the stream as a Corridor because of the wide spread wetland formed in this specific area. Trees formed as patches in some portions, but the meadow wetland formed between the wetland and the forest demarcated the boundaries (Edge). A road located at the center of the wetland divided the wetland into two sections nevertheless, both the separated wetlands still maintain similar forms of vegetations.

The wetland area at the rear part of Sami stream is situated at the Yeoncheon county, still within the province of Gyeonggi. There used to be villages and farmlands in this area in the past. Presently, the area transformed into natural landscape patterns since human access has not been possible. A matrix wetland formed in the rear part of Sami stream and Woodland patches formed in the middle portion. Sami stream flows from south to the north corridors of the DMZ. The bushes in the neighboring area acted as buffer zones between the wetland and forest ecosystems. This area has high landscape ecological value. It is a favorite heaven for migratory birds and wild animals (Fig. 2.17).

The picture shown in Fig. 2.18 is the Gowang mountain area, still within the Yeoncheon county. It has typical mountain landform forming a forest-based Matrix.



Fig. 2.18 Landscape ecological pattern in Gowang mountain area



Fig. 2.19 Landscape ecological pattern in the Yeokgok stream area, Cheorwon

The Sami stream which flows in this forest becomes stream corridors of wildlife. There are wetland patches observed between the stream and the forest.

Cheorwon Yeokgok Stream Area

This area of the Cheorwon is where the Yeokgok stream flows. It is a fairly large stream that flows mostly in the entire DMZ among other streams flowing here. Actually, Yeokgok water flows across the entire country. This area of the DMZ is also well preserved since it enjoys almost no interference or disturbance from the outside civilization for a long time. A wetland vegetation is widely developed along the Yeokgok stream.

This Yeokgok stream forms corridors and landscape ecological patterns with diverse wetland vegetation of various bushes and trees. The wetland is wide spread and forest Matrix eventually formed patches near Yeokgok stream (Fig. 2.19).

Figure 2.20 presents an image of the Yeokgok stream expanding down to Pilseung observation point (OP) of the Cheorwon. What is significant about the Yeokgok stream is that, it is located deep inside of DMZ, and it is almost the sole



Fig. 2.20 Landscape ecological pattern in Pilseung OP area, Cheorwon

source of the surrounding very well-developed vegetation. It forms major corridors and adjacent to it, there are patches of wetland formations and in the plains' Landform are grasslands and forest Patches. In a landscape ecological aspect, diversified patterns are formed of relatively various types of patches.

As it is shown in most of the landscapes in the DMZ, roads are not visible but it shows the cease-fire line passing across the middle as shown in Fig. 2.20. As a result, these cease-fire lines in many sections of the DMZ actually disconnects the habitats. This resultant disconnection made by the cease-fire lines, including the roads constructed across the conserved landscape, are considered as 'disturbance' elements, an interrupting factor for the migration of wildlife and the succession of plant ecosystem, which required access to interrelating processes of plant gene propagation. The DMZ's ever developing environmental ecology and genealogy must be given high value by this Peninsula, and perhaps by the whole world. Hence, alternative management actions should be installed through joint



Fig. 2.21 Landscape ecological pattern in the upper area of the Northern Han river

governance and convergence of resources of both North and South Korea for the main purpose of protecting and sustaining the DMZ.

Northern Han River Area

The Northern Han river is the primary tributary that flows from Gangwon province through the Gyeonggi provincial areas and then finally joining with the Southern Han river in Yansoo ri. Figure 2.21 presents the upper river area within the Northern Han river sections, which is surrounded by dense forests in both sides of the stream. Wetland is not widely developed since water resource is tantamount to the needs of the density of the forest and the landscape does not permit such storage of surface waters. The composition of this area are mostly Woodland patches that protect the area from floods, small meadow wetlands are also formed, while lush shrubs and bushes buffer the boundaries (Edge) between the stream corridors and the forest Matrix thereby protecting the area from silt and soil erosion.

Cheorwon Hantan River Area

The Hantan river originated from Gangwon province, passing through the Gimhwa, Cheorwon, Pocheon, Yeoncheon, and joins the Imjin river that flows across the long and narrow Chugaryeong valley. This valley was formed by volcanic materials spurted by the volcanic explosion in the remote past. Subsequent cliffs and valleys were developed allowing the river basin to be formed. The steep forest patches that are directly next to the corridors of the streams of Hantan river can be clearly seen in Fig. 2.22 as well. Shrubs and bushes also form the boundaries between the stream Corridor and the forest patches in some sections. The wetland that functions as a riparian buffer area near the stream is hardly seen in this picture.

Cheorwon Namdae Stream Area

The Namdae area nurtures a stream that originated from Oseong mountain of North Korea flowing down to Hantan river after passing a 50 km radius of land to the south, then finally to the DMZ. The stream passes across the farmlands that spread out in Namdae and Gimhwa-town down to the Gimhwa plain. Figure 2.23 features the



Fig. 2.22 Landscape ecological pattern of Cheorwon Hantan river and surrounding wetland



Fig. 2.23 Landscape ecological pattern in Namdae stream area, Cheorwon

stream that branches out to the Gimhwa, Namdae, and Gimhwa plain. The forest formed along the stream is also vividly shown dominating the whole area. The forest patches formed in the mid portion act as a corridor of the stream and the road.

Goseong Anho Reservoir Area

The Anho Reservoir is located in Goseong county, Gangwon province. This is the area where the most astounding metamorphosis of the wetland ecology has been displayed. It is a conglomeration of plain, estuary, coastline, and valley wetlands evenly distributed and that have highly developed ecosystems. These features, therefore, are equally and highly distinguished to be maintained.

The picture shown in Fig. 2.24 is the actual documentaries of the Anho Reservoir. The coastal wetland corridor is the most prominent feature that is beyond



Fig. 2.24 Landscape ecological pattern near Anho Reservoir, Goseong

comparison and cannot be seen in the other landscapes of the DMZ areas. Vegetation near the Anho Reservoir may have incomplete settlement but the wetland vegetation in the boundaries (Edge) is distinctive. Patches are also observed along the wire fences surrounding and crisscrossing inside and out of the reservoir. This was made possible because human access is restricted.

2.3.3 Landscape Ecological Analysis Based on Landscape Physiognomy and Composition

This section presents the analysis of findings based on Landscape Ecology theories and methods introduced and applied in one area of the DMZ utilizing satellite imaging and actual ocular survey.

Figure 2.25 shows different mosaics of habitats. It was known that the variance in geomorphological process in this landscape is attributed to the degree of human interference and the area was exposed to.

Dandelion Fields in the Hantan River Basin

Mindeulle plain is the first pilot study area for the landscape physiognomy and composition.

The agricultural area formed a very uniform homogeneous landscape with short (straight-line) boundaries relative to the geographic outlines of the areas. As it is located in the central part of DMZ, the farmland having temperate climate has been converted into wetland due to 60 years of noncultivation and filled up by the Han river that connects the south to the north (Fig. 2.25).

The Mindeulle plain in DMZ Hantan river basin is a large-scale process landscape. The plants and animals migrate together by genes, energy, and nutrients that have been transported through wind and water. Networks of corridor rivers, also known as roadside verges provide routes for some species to move between habitat patches to another. The biological transfer is dependent on the climate within the valley, and the movement of soils and water down to the valley (Fig. 2.26).

This ecological properties of landscapes can be measured in terms of physiognomy and composition point of view (Fig. 2.27).

The Landscape Physiognomy of Mindeulle plain can be calculated using the length of patches' boundaries and the distance between patches, ponds, and wetlands habitats.

Through systematic observation during ocular surveys, the Landscape composition of Mindeulle plain noted to be highly heterogeneous apart from the mosaic patches but associated to the Hantan river and the tributary corridor network. Ridges are traces between rice paddies and houses and, within the military check route which is believed to have contributed to the formation of these various types of patches. Patch types discovered in this landscape are: disturbance patches,



Fig. 2.25 Two landscapes in the DMZ. **a** DMZ Hantan river basin: Mindeulle plain area. **b** DMZ Sacheon river basin: Panmun field area. **(a)** with low degree of human interference and **(b)** high degree of human interference. These examples contain a number of different ecosystems



Fig. 2.26 Landscape physiognomy and composition of DMZ Hantan river basin: Mindeulle plain



Fig. 2.27 Patch types of Hantan river landscape

regenerated patches, environmental patches, remnant patches, and introduced patches classified by Forman.

2.3.4 Landscape Ecological Analysis Based on Ecological Network (International Biosphere Belt (IBB))

The DMZ ecosystem is very significant in itself, but it may also play a crucial role in eco-network in the Korean peninsula and even in the entire Eurasia. With this end in view, a conceptual plan that valued the study area as a starting point, and the establishment of a core base of Northeast Asia and Eurasia ecologic-network was developed (Fig. 2.28).

2.3.4.1 North-East Ecological Network

The study area is located in the central part of the Korean peninsula and is connected to the tidal flat in the western coast, wetland, and the Han river estuary. Expanding in a 155 mile-long DMZ and CCZ, it is linked to the central area of the Korean peninsula and forms an ecologic belt ranging from the western coast to the eastern coast. Such geographic features allow the formation of a natural Ecosystem Belt stretching from the tidal flat to the valuable natural resources in the western coast up to the Paikdoo main range in the eastern area. This ecosystem network arrangement continues to link Paikdoo main range to Mt. Kumgang, to Mt. Paikdoo, up far to the large wetland in Korea–China–Russia border area. The network now expands and forms the Northeast Asia ecological network. The proposal is described more in detail in Chap. 10 of this book (Figs. 2.29 and 2.30).



Fig. 2.28 DMZ biosphere concept

Fig. 2.30 Connecting to Mt. Kumkang and western wetland belt



Fig. 2.29 Connecting the west to the east of DMZ



2.3.4.2 Global Ecological Network

This North-east Asia eco-network may develop further toward Central Asia and to EECONET (the eco-network in Europe). Such a network will provide a good opportunity to promote mutual understanding and management on ecosystem in Europe and Asia. This network opens door for academic exchanges that can strengthen ecological functions of all nations.

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