CHAPTER 10

LANDSCAPE ECOLOGY FOR BIODIVERSITY

Scaling up

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Abstract. Biological diversity has been emerged as a core concept in management and conservation of diverse ecological systems. Scaling up for biodiversity conservation in landscape system is also emerging issue in ecologists. In order to conserve biodiversity from the genetic level to ecosystem and landscape levels, multi-scale strategies and efforts are being adopted and executed in many countries. In this paper, comprehensive and necessary considerations arisen from the view of landscape ecology were discussed for the present situations of wildlife conservation and management in Korea compared with other countries. Especially, the conservation strategy and policy of biodiversity were addressed in broad senses including habitat protections, legal approaches, landscape design and ecological network programs.

1. WORLD'S WILDLIFE: STATUS AND CRISIS

Landscape factors—the natural and artificial types of lands including types of utilization of lands by man—are the parts of a general landscape that looks common in sight and provide species with diverse ecological systems such as habitats. The spatial factors in landscape are naturally arranged and built by the environmental inclination. However, the habitats of living things ruined by inconsiderable utilization of land by man has recently become a threat to the survival of living things as the landscape mosaic becomes simpler (Ro et al., 2000). The phenomena in biodiversity that are caused by this rapid change of landscapes are mainly classified into two: the acceleration of the extinction rate of species and the increase of biological invasion by alien species. These two characters of the phenomena occur simultaneously and complement each other (Spellerberg, 1996; Szaro and Johnston, 1996). Therefore, the landscapes plan for biodiversity conservation strategy of natural wildlife should be made under the policy that can supplement these two. The followings are predictions of the species extinction (UNEP, 1995; Washitani, 1999).

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- Around 15~20% of species on earth will disappear from 1980 to 2000.
- Of the 250,000 species of vascular plants, 1,000 have already been extinct for the last 100 years and 60,000 more are predicted to be extinct within 50 years.
- There is a possibility that 1/4 of the world's total biodiversity might be extinct 20~30 years from now.
- Thousands of unclassified insects become extinct every year.
- 17,500 species or 0.1% of the total species become extinct every year.
- Half of the terrestrial species will be extinct within 50 years.
- Half of species on the earth will be extinct from 1990 to 2015.

The direct cause of extinction is the destruction of habitats, often by lumbering, fire, reclamation, and dredging. Habitats are becoming more limited because the diverse natural ecosystems are converted into farmland, or into urban ecosystems of cities in worse cases. The limited population density is threatened by the reduction of population caused by capture and over collection. And the possibility of extinction of living things increases due to environmental pollution such as water pollution, air pollution and soil pollution from insecticides and herbicides. Some lakes in north Europe have become 'lakes of death' because all the organisms in the lakes died due to acid rain. The artificial changes of natural environment occurring in the entire world can be summarized as follows (Spellerberg, 1996; UNEP, 1995; Szaro and Johnston, 1996).

- Extinction by natural causes
- Isolation between terrestrial ecosystem and water ecosystem in the area
- Fragmentation and simplification of habitats
- Change of habitat quality
- Destruction of habitats, capture of specific species, and environmental pollution

These are the main causes of the extinction of organisms. Most of these are due to the increase of human population.

2. APPLICATION OF THE PRINCIPLE OF LANDSCAPE ECOLOGY

The landscape mosaic has different ranges of organisms with different distribution structures of species according to the landscape elements (such as forests, pasture, stream, and farmlands) that compose the landscape structure. Therefore, species migration is also functionally different according to juxtaposition of landscape elements. The heterogeneous landscape, composed of different types of landscapes, increases the number of large-sized mammals or the edge species that inhabit neighbouring landscape elements. Thus, the diverse species of living things grow in number. Likewise, the increase and decrease of species in a landscape both influence the landscape heterogeneity and are influenced by the landscape heterogeneity. Landscape heterogeneity varies according to the degree of disturbance and landscape stability (Turner and Gardner, 1991; Hong, 1999). The characters of landscape influence landscape stability, which is the capability to cope with the disturbance (Cox, 1993; Forman, 1995; Ro et al., 2000).

From the landscape ecological viewpoint, migration and distribution of organisms have close relations with structure, pattern, and arrangement of landscape elements that compose a landscape. Landscape ecology has similar approaches such as those of the existing ecology. In one sense, landscape ecology is based on the principle of the existing ecology. However, it is different from the existing ecology in that landscape ecology observes the interaction between the organisms in the ecosystem complex that is composed of 'landscape elements,' which are a spatial measurement in the landscape scale (Forman and Collinge, 1986; Zonneveld, 1989).

Various fields related to ecology such as forestry and landscape architecture have used the principle of landscape ecology for the basic forest planning and management, park, suburban development, and design for the river corridors and habitat. Meanwhile, conservation biologists including the managers of national parks and resorts use the principle of landscape ecology for protecting land, restoring it, and conserving biodiversity. Landscape ecology contributes to the development of policies, management, conservation, design, and planning of landscape under the hypothesis that natures and human beings maintain mutual relations. Landscape ecology also suggests beneficial understanding and prediction regarding the conflicts that people may have with natural environments such as high forest productivity, conservation of species, clean water, establishment of dams, and development of residential areas and resorts. Therefore, landscape ecology includes not only interaction between organism and environment in which the ecology is currently interested but also multi-disciplinary fields about human beings (Hong, 2001; Farina and Hong, 2004). The ultimate goal of landscape ecology is to carry a potential role for sustainability. This is possible only through proper prescription focused on landscape ecology conserving a landscape designed by the land development that can effectively satisfy the ecological integrity and the basic desires of human beings from generation to generation.

3. BIODIVERSITY CONSERVATION: ISSUE OF SCALES

In order to conserve biodiversity properly and effectively, the conservation of species and population of animals and plants as well as the protection of habitats and environment must be given high importance. There are differences in the ways of conservation. For instance endangered species may be bred in a zoo, a botanic garden, or in protection cages (*ex situ* conservation) for the conservation purpose. Conservation of the population can also be done in the original habitats (*in situ* conservation) (Naveh, 1994).

Taxonomy and ecology have taken an important role to protect the natural environment. However, the researches from academic fields do not have enough relation with population genetics that provides important knowledge about the protection and conservation of organisms. What makes landscape ecology different from the existing ecosystem and classical application and categorization to protect nature is that landscape ecology positively adopts the accomplishment and technology of new academic fields such as modelling and spatial ecology. Furthermore, relations of the academic system with other academic fields can be explored in researches (Cox, 1993; Forman and Collinge, 1996, Farina and Hong, 2004). That is why landscape ecology is considered worldwide as an important academic field. The followings are researches about biodiversity from the viewpoint of landscape ecology (Washitani, 1999).

- Understanding of general theology: the mechanism of existence and conservation of biodiversity is an important theme of research in landscape ecology.
- Research on the conservation of species, population, and communities of living things.
- Research on the habitats, the conservation of landscape, restoration, and management of landscapes.

Through these researches, landscape ecology makes an important turning point that changes the existing standard of evaluation on the value of nature from centering on naturalness to centering on biodiversity.

4. ALTERNATIVES FOR THE CONSERVATION STRATEGY

4.1 Hierarchical Approach

Biodiversity can be defined as a concept with hierarchical character, structural character, and functional character. These can be categorized based on four levels of 1) gene, 2) species or population, 3) community or ecosystem, and 4) landscape. The strategy for conservation is set up and carried out based on such a systematic level (Table 1).

Table 1. Characters and factors in the concept of biodiversity.

Hierarchy	Composition	Structure	Function
Landscape	Landscape type	Landscape pattern	Process and distribution of landscape, Land use pattern
Community-ecosystem	Community type, Ecosystem type	Relationship, Habitat structure	Interaction among species, Ecosystem process
Species-population	Species, Population	Population structure	Life history Population process
Gene	Genetic composition	Genetic structure	Genetic process

4.1.1 Species population and community levels

To determine the worldwide state of extinction of wildlife, it is necessary to research on the actual condition about which species exist under specific circumstances. For this purpose, the countries in the world classify the species that could possibly be extinct out of the various fauna and flora based on a certain standard of evaluation (*Red List* or *Red Data Book*). The standards used as the degree of extinction in Red Data Book are decided by IUCN.

- *Extinct species* (Ex): The species that cannot be found in the outdoor research field for the past 50 years.
- *Endangered species* (En): The species that are considered to be extinct without policies for protection.
- *Vulnerable species* (V): The species that have a possibility to be extinct eventually, even if there is no danger of being extinct in a short period.
- *Rare species* (R): The species that have especially low population, although there is no cause to reduce the population.
- *Unknown species* (U): The species whose state of survival cannot be evaluated because of impossibility to figure out the number of population.

The probability of extinction is decided according to the Population Viable Analysis (PVA) in order to make the standard based on fixed quantities while excluding the subjectivity of such categories. Recently, IUCN (2000) adopted the idea and published the Red Data Book based on the new standard. In this new standard, the species about which material collected based on population are categorized into three, namely, extinct species, threatened species, and low risk species (LR).

Table 2. The standard of evaluation by IUCN about extinct and endangered species.

Category	Extinct species	Endangered species	Vulnerable species
A. Rapid reduction	Reduction to less than 20% within 10 years or in third generation	Reduction to less than 50% within 10 years or in third generation	Reduction to less than 80% within 10 years or in third generation
B. Small distribution range (short, continuing reduction, big change)	Distribution range is less than 100 km^2 or habitat is less than 10 km^2	Distribution range is less than 5,000 km^2 or habitat is less than 500 km^2	Distribution range is less than 20,000 km^2 or habitat is less than 2,000 km^2
C. Small group (continuing reduction)	The population of grown-ups is less than 250	The population of grown-ups is less than 2,500	The population of grown-ups is less than 10,000
D1. Very small group	The population of grown-ups is less than 50	The population of grown-ups is less than 250	The population of grown-ups is less than 1,000
D2. Very small distribution range	-	-	Distribution range is less than 100 km^2 or 5 places
E. Probability of extinction	Having probability of extinction with over 50% of reduction within 10 years or in third generation	Having probability of extinction with over 20% of reduction within 20 years or in fifth generation	Having probability of extinction with over 10% within 100 years or in fifth generation

The extinct species category is divided into extinct (EX) and extinct in the wild (EW). The category of low risk species (LR) includes conservation dependent species (cd), near threatened species (nt), and minimum concern species (lc). Extinct and endangered species that have a problem in conservation are classified in detail as follows (IUCN, 2000; Washitani, 1999).

4.1.2 Habitats and landscape levels

The strategy for biodiversity conservation is classified into five categories, which are the designation of reservation area (Table 3), the ecological network plan, the conservation by law and regulation, the conservation outside the reservation area, and the conservation of the facilities. The most typical and classical way of conservation of species is the restriction of human activities by designating core areas for conservation of wildlife as reservation areas. An ecological network plan is based on the idea to conserve the remaining habitats both in highly valued area and in low valued area for nature, and to connect them ecologically by coordinating the strategies for conservation for inside reservation area and outside reservation area. Furthermore, the connection by protection outside reservation areas, conservation in artificial facilities, and conservation by laws and regulations are also very important.

4.2 Ecological design

4.2.1 Necessity

A habitat patch, a spatial element that composes the landscape mosaic, is distinguished from neighboring areas and relatively equalized areas for habitats of wildlife. The patches of habitats have well-known characters such as large, small, round, long, straight, or bent borders. Contrary to habitat patch, the habitat corridors have lined structures. Those characters widely give the ecological meanings to productivity, diversity, soil, and humidity (Forman and Godron, 1986; Forman, 1995; Farina, 2000).

The mosaic with moving habitat patches can generally be considered as a part of a land transformation process or a part of a process of landscape change. The corridors and matrix of the landscape are also in the state of moving. The species and the process of ecosystem are also changed. In fact, community succession is one of the courses that decide speed and direction of change inside the habitat patches caused by human activities (artificial). The lands on the slopes of a mountain can be forests, farm lands, swimming pools, or exposed rocky places according to what kind of force caused the main force among biological succession, farming tractors, excavation equipment, or erosion. Therefore, the patches can be changed into the various directions. Furthermore, landscape can be degenerated, grown, or can remain in stability. In the meantime, a landscape can be diverged into many directions and have other shapes.

For instance, in case of the forest that disappeared because of edge effect and soil erosion by cutting off with construction of forest roads, the success of regeneration process depends on the patch size of the forest.

Table 3. Kinds and contents of the reservation area according to IUCN.

Area	Category	Contents
Absolute reservation area	Absolute nature and reservation area for wild life	-Areas that are absolutely reserved for scientific research, education, and environmental monitoring -The areas should be protected from human beings' influence as much as possible as possible
	National parks	-Areas with beautiful views of nature reserved for protecting ecosystem, scientific research, education, and recreation -Commercial utilization is not allowed.
	Natural monument, Landmark of nature	Areas that are under special care because of biological, geographical and literal particularities
	Habitats for wildlife, Reservation area	Areas that are under control to conserve the special biological communities
	Landscape reservation area	-Areas with cultural or ecological particularities that allow classical utilization but not destructive utilization -The territories can be used for recreation or tours.
Control area	Natural resource reservation area	Areas that are under restriction for the conservation of natural resources as long as the restriction does not conflict with any government policy
	Reservation area for biological resource and anthropology	-Areas that allow livelihood of human beings in a traditional way -Traditional farming is allowed.
	Control area for the multi-purpose utilization	Areas that allow the utilization of natural resources such as water, wildlife, pasture, lumbering, and tours

In the reservation of lakes and aquifer connected to rivers, the quality of water depends on neighbouring patches of natural vegetation with a large size. Therefore, when the reservation areas of nature are designed, it should be decided whether one large sized patch or several small patches would be ideal.

4.2.2 Concept

The most general methods for the designation of reservation area are the policies of government and the purchase of lands by individuals or nature protection institutions that can restrict human activities. Recently, the designation for reservation area by government or environment protection organizations has widely accelerated. Legal reservation area in the worldwide occupies 5.9% of the whole earth. With regard to the limitedly permitted human activities inside a reservation area, IUCN established the international uniform standard and the categories which consist of five absolute reservation areas and three control areas in 1978 as explained in Table 3.

The principle of the plan for the designation of reservation areas for biodiversity was proposed by Diamond in 1975 based on island biogeography (MacArthur and Wilson, 1967; Diamond, 1976; Forman and Godron, 1986; Spellerberg, 1996; Jongman and Pungetti, 2004). It is not clear whether a large-sized patch of habitat or a small-sized patch of habitat is better in the ecological sense (large or small; LOS). It is also uncertain whether only one large-sized patch or several small-sized patches are better in an ecological sense (single large or several small; SLOSS). It is not a simple job to compare ecologically a large-sized patch of habitat and a small-sized patch of habitat. The types and environment of habitats need to be identical. If not, the size can be confused according to both the types of habitats and the diversity of habitats. There are many different opinions about LOS and SLOSS. Some people consider that one large-sized patch is more beneficial to conserve organisms. On the other hand, some insist that several small-sized patches are more beneficial.

The plan of Man and Biosphere (MAB) of UNESCO, which designates 329 Biosphere Reserves (BRs) in the world and coordinately carries out for human activities, research, and conservation of natural environment, is a pioneering example in the approach of reservation areas. BRs areas include three kinds of zones. In the *core zone*, the communities and ecosystem should be absolutely protected. The core zone should be ecologically connected to another zone through an ecological corridor. The core zone is surrounded by the buffer zone. In the *buffer zone*, a plan for the multi-utilization of land should be made in order to achieve harmony between human activities and biodiversity. In the buffer zone, traditional human activities, such as the collection of herbs, and non-destructive research and monitoring are allowed. However, such plans for the reservation areas still have problems. Therefore, in order to designate "nature reserve area," the following should be resolved first.

- *Prior nature reserve area cannot represent the entire natural communities.* Generally, nature reserve areas are established for breeding and habitation of special animals and plants that need to be conserved. In spite of this, nature reserve areas cannot have perfect ecosystems for habitation of specific organisms.
- *Most nature reserve areas are too small to conserve the population and all the process of ecosystem.* Each species has a different ecological characteristics and life pattern. The minimum sized population required for species to be

conserved from the viewpoint of environmental biology, or the Minimum Viable Population (MVP), is closely related with the habitat size. Large-sized patches are fragmented because of human impact. In such a case, there is a possibility that species might be changed to metapopulation which cannot conserve the population size for survival.

- *Usually, the migration of animals expands outside nature reserve area.* In particular, the habitats of birds and its range of territory are flexible. Therefore, the nature reserve area should include breeding and feeding places as well as habits.
- *The nature reserve area does not consider the influence caused by utilization of lands in surrounding areas.* It is the best for the nature reserve area to be built by using the resources of natural ecosystem while reserving the natural environment. An ecotope map has already been made and used in the developed countries in order to find the geographically proper place for conservation. An ecotope map is composed of the biological biotope map used as a control unit of environmental plan and conservation of minimum number of species for the habitats of correlatively similar kinds of animals and plants (Whittaker, 1975; Zonneveld, 1989; Haber, 1994; Riitters et al.,1997; Farina, 2000; Hong, 2002a, b). In addition, it also contains the drawings for the general contents about physiotope and anthrotope of ecosystem to support the ecological function of biotope according to its units. The physiotopes such as soils, weather factors, and temperatures, which are very important for habitats and activities of organisms, are drawn and measured by number (Hong et al., 2004; Nakagoshi et al., 2004). Lastly, the plan for "ecological network system" can be made based on an ecotope map that can help understand both ecological structure and function (Choi, 2004; Hong et al., 2005).

4.2.3 Design

In order to conserve biodiversity, a proper nature reserve area should be designed and protected. If necessary, the area should be properly controlled. How the fragmentation and isolation of habitats influence biodiversity should also be seriously considered? In other words, the problems that can occur in the fragmentation process, such as the changes in environmental condition for the population and communities that need to be conserved or the biological invasion in fragmented habitat patch, should be fully considered. Even though there are general guidelines regarding the location, number, and type of habitat patch in nature reserve areas, the first concern for the design should be focused on the relationship among the habitat area, the effect of conservation and the decision of patch type in order to minimize an edge effect. A buffer zone is another important consideration to prevent disturbance and invasion of exotic organism caused by an edge effect. Lastly, it should be fully realized that area-perimeter ratio is reduced, as the area of the habitats patch gets smaller when a large-sized patch changes into several small-sized fragmented patches. Until now, the relations with biodiversity conservation are explained by mainly centering on the structure and function of the habitat patch among the spatial factors that compose landscape mosaic. However, because the habitat patches and corridors in landscape mosaic are spatially connected with each other in matrix, it is necessary to mention these two spatial factors. In the ecological functions of the corridors of habitats such as rivers and roads, which serve as sources and sinks for species, the functions are major issues that should be considerably studied.

5. CONCLUSION

The principle of "network system" is used, from the viewpoint of landscape ecology (Naveh, 1994; Jongman and Pungetti, 2004), as the strategy to obtain various types of patches where the diverse organisms live. It is also used to improve the quality of biodiversity and to reinforce the recent policies for conservation and management of wildlife such as the establishment of nature reserves area. The strategy, so called "ecological network", "biotope network" or "habitat network", is for the improvement of ecosystem quality in an entire region. It is based on the assumption that ecological corridors are effective for migration and distribution of animals (Hong et al., 2004). Through the networking system, the habitats existing in the region can be kept eco-functionally in the connected system. Such concepts and methods of ecological networks are being actively preceded in European countries starting from Germany. It has also been especially developed, being classified to land use planning and landscape ecological planning.

- *Core areas* should be regions with high biodiversity and high naturalness that have the typical and representative habitats where the rare and endangered species live. Core areas should also be larger than the minimum-sized area required for the survival of organisms. In Europe, domestically and internationally, the required minimum size of the core area is 500 ha.
- *Ecological corridors* should be areas with a good connection with core areas. They should function as temporary habitats and routines for migration and distribution. In choosing ecological corridors, the size of core areas for connection and the distance from adjacent habitats and existence of obstacles should be considered.
- *Nature development areas* should have some naturalness and should function as buffer zone that prevents the habitats in core area and corridors from artificial influence. They are also the restoration places for nature to reinforce and expand the ecological networks.

Ecological network concept is generally accepted as one of broad disciplines that cover diverse type of ecological corridors such as river continuum (blue network) and forest connectivity (green network) (Jongman and Pungetti, 2004, see Chapter 30). The continuity or connectivity among various sized ecosystems in aquatic and terrestrial systems is the matter of sustainability. In Korea, the blue-green network concept has been applied to the early stage of urban planning for the construction of Administrative Multifunctional City (73.14 km^2) in middle part of Korea. As a part of environmental impact assessment (EIA) procedures, Preliminary Environmental Review (PER) was conducted, and PER statement described and analysed natural environment characteristics of several candidate locations.

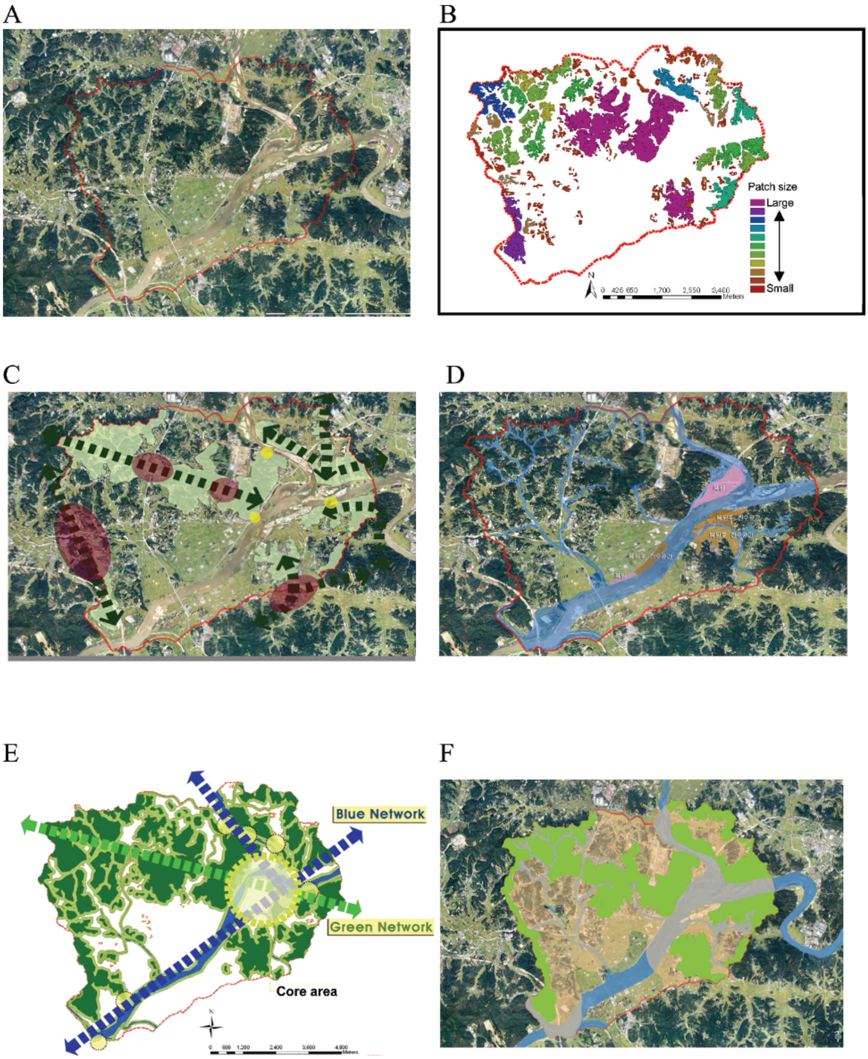

Figure 1. Ecological network analysis and conservation strategy for Administrative Multifunctional City, which is planned to locate in southern part from Seoul, Korea (supported from Korea Environment Institute, Seoul).

An example of blue-green network analysis conducted in this task is shown in Figure 1A-F. Patch analysis has been applied to identify the priority of conservation area in land use planning step. Conservation priority of forest patch has provided major green axes in and around the candidate city's boundary (Figure 1B). Fauna and flora survey carried out to obtain biological and ecological information. Based on the information, core area and corridors are identified and planned to be protected

(Figure 1C and D). At same time, the lists of wildlife animals and plants that should be reserved in the area are also screened, and their conservation program is proposed. The conceptual blue-green network plan is produced by overlap the river continuum and green axes in the area (Figure 1E). Finally, detailed land use plan is shaping up depending on the functional schemes of the new city

In the operated plans for conservation and restoration of biodiversity in many countries such as Netherlands and Germany (Jongman and Pungetti, 2004), there is a concept that inter-habitat networking are established in the regions and in a country even to the extent of the entire continent. In Europe, the plan, together with social economic methods for the establishment of networks and conservation of important habitats, proceeds at the spatially hierarchy level of European continent, countries, provinces, regions, territories and villages. As the cases of the developed countries are shown in the above, the biodiversity conservation needs the systemic measurement that is used not only for the populations' conservation but also for the conservation of habitats at the level of region and landscape (Cox, 1993; Forman and Collinge, 1996; Washitani, 1999). It is also used for the common sharing management and conservation through international relations for organisms with a wide range of activities.

Interdisciplinary theories and concepts of landscape management and planning for nature-human system are emerging issues (Zonneveld, 1989; Ro et al., 2000; Farina and Hong, 2004). The issues are effectively concerned with nature resource management and sustainable development in environmental policy. Finally, authors suggested that landscape ecology has to provide the baseline framework not only for ecological research and monitoring but also general protocol of environmental policy in a changing world.

REFERENCES

Choi, Y.-K. 2004. Linking planning system between spatial development plan and environment plan toward sustainable development. In S.-K. Hong, J.A. Lee, B.-S. Ihm, A. Farina, Y. Son, E.-S. Kim and J. C. Choe (Eds.), *Ecological Issues in a Changing World: Status, Response and Strategy*. Kluwer Academic Publishers, Dordrecht, The Netherlands.

Cox, G.W. 1993. *Conservation Ecology*. Wm. C. Brown Publishers. 352p.

Diamond, J.M. 1976. Island biogeography and conservation: Strategy and limitation. *Science*, 193, 1027-1029.

Farina, A. 2000. *Landscape Ecology in Action*. Kluwer Academic Publishers. Dordrecht, The Netherlands.

Farina, A. and Hong, S.-K. 2004. A theoretical framework for a science of landscape. In S.-K. Hong, J.A. Lee, B.-S. Ihm, A. Farina, Y. Son, E.-S. Kim and J.C. Choe (Eds.), *Ecological Issues in a Changing World: Status, Response and Strategy*. Kluwer Academic Publishers, Dordrecht, The Netherlands.

Forman, R.T.T. 1995. *Land Mosaics: The Ecology of Landscapes and Regions*. Cambridge University Press. Cambridge.

Forman, R.T.T. and Collinge, S.K. 1996. The spatial solution to conserving biodiversity in landscapes and regions. In R.M. DeGraaf and R.I. Miller (Eds.), *Conservation of Faunal Diversity in Forested Landscapes* (pp. 537-568). Chapman & Hall.

Forman, R.T.T. and Godron, M. 1986. *Landscape Ecology*. John Wiley & Son, New York.

Hong, S.-K. 1999. Cause and consequence of landscape fragmentation and changing disturbance by socio-economic development in mountain landscape system of South Korea. *J. Environ. Sci.*, 11, 181-187.

Hong, S.-K. 2001. Factors affecting landscape changes in central Korea: Cultural disturbance on the forested landscape systems. In I.S. Zonneveld and D. van der Zee (Eds.), *Landscape Ecology Applied in Land Evaluation, Development and Conservation* (pp.131-147), ITC Publication No. 81, IALE publication MM-1, Enschede, The Netherlands.

Hong, S.-K. 2002a. Necessity of landscape ecology in environment impact assessment of natural resource and action of IALE network. *Nature Conservation*, 120, 32-38. (in Korean)

Hong, S.-K. 2002b. Man-influenced vegetation in Korea: Landscape ecology, management and planning. In D. Lee, J. Virginia, J.C. Choe, Y. Son, S. Yoo, H.-Y. Lee, S.-K. Hong and B.-S. Ihm (Eds.), *Ecology of Korea* (pp. 156-178). Bumwoo Publishing Company, Seoul.

Hong, S.-K., Kim, S., Cho, K.-H., Kim, J.-E., Kang, S. and Lee, D. 2004. Ecotope mapping for landscape ecological assessment of habitat and ecosystem: A case study at man-influenced rugged landscape. *Ecological Research*, 19, 131-139.

Hong, S.-K., Song, I.-J., Byun, B.-S., Yoo, S. and Nakagoshi, N. 2005. Applications of biotope mapping for spatial environmental planning and policy: Case studies in urban ecosystems in Korea. *Landscape and Ecological Engineering,* 1(2), 101-112.

IUCN. 2000. *2000 IUCN Red List of Threatened Species*. Gland, Switzerland and Cambridge, UK. 61pp.

Jongman, R. and Pungetti, G. 2004. *Ecological networks and greenways: concept, design, implementation*. Cambridge University Press. 345p.

MacArthur, J.W. and Wilson, E.O. 1967. *The Theory of Island Biogeography*. Princeton University Press, NJ.

Nakagoshi, N., Watanabe, S. and Koga T. 2004. Landscape ecological approach for restoration site of natural forests in the Ota river basin, Japan. In S.-K. Hong, J.A. Lee, B.-S. Ihm, A. Farina, Y. Son, E.-S. Kim and J. C. Choe (Eds.), *Ecological Issues in a Changing World: Status, Response and Strategy*. Kluwer Academic Publishers, Dordrecht, The Netherlands.

Naveh, Z. 1994. From biodiversity to ecodiversity: A landscape-ecology approach to conservation and restoration. *Restoration Ecology*, 2, 180-189.

Riitters, K.H., O'Neill, R.V. and Jones, K.B. 1997. Assessing habitat suitability at multiple scale: A landscape-level approach. *Biological Conservation*, 81, 191-202.

Ro, T.H., Hong, S.-K., Kang, D.-S. and Kwon, O.-S. 2000. *Ecology: Nature and Man*, Academy Press, Seoul.

Spellerberg, I.F. 1996. *Conservation Biology*. Longman. England. 242pp.

Szaro, R.C. and Johnston, D.W. 1996. *Biodiversity in Managed Landscapes. Theory and Practice*. Oxford University Press. 778pp.

Turner, M.G. and Gardner, R.H. 1991. *Quantitative Methods in Landscape Ecology: The Analysis and Interpretation of Landscape Heterogeneity*. Springer-Verlag, New York.

UNEP. 1995. *Global Biodiversity Assessment*. Cambridge University Press. 1140p.

Washitani, I. 1999. *Ecology of Biological Conservation*. Kyoritsu Publisher, Tokyo, Japan (in Japanese)

Whittaker, R.H. 1975. *Community and Ecosystems*. McMillan Publishing, New York.

Zonneveld, I.S. 1989. The land unit - A fundamental concept in landscape ecology, and its applications. *Landscape Ecology*, 32, 67-86.