한국조경학회지 33(3): 1~17, 2005. 8.
Journal of the Korean Institute of Landscape Architecture

진보된 경관특성평가 방법론

김근호

영국 맨체스터대학교 도시조경학부

An Advanced Methodology of Landscape Character Assessment

Kim, Keun-Ho

Researcher, School of Planning and Landscape & Centre for City and Regional Ecology, Oxford Road, Manchester, M13 9PL, England

ABSTRACT

오늘날 지속가능한 발전의 주요 목적으로서 환경의 효과적 보호와 신중한 자연자원의 이용이 강조된다. 이와 같은 목적들을 성취하기 위해서 종합적인 경관 정보가 필수적이다. 한국의 경우, 도시화는 전통적인 농촌 경관 변화, 산림 손실과 단편화 등 많은 환경 문제를 야기했다. 특히 산림이 높은 생물 다양성 가치를 갖고 있는 한국으로서는 산림 손실과 단편화는 생태관점에서 보면 아주 치명적이다. 현재 개인 또는 공공 부분 개발 프로젝트를 위한 환경 영향 평가의 일부분으로 시각 경관 영향 평가가 요구된다. 그러나 이런 시각 경관 영향 평가는 단지 전체 경관의 일부분의 경관 정보만을 제공하고, 특히 현재 경관 평가에서는 경관의 생물 다양성 가치를 평가하지 않는다. 본 연구는 이와 같은 문제점들을 극복하고 한국 상황에 맞는 지속가능한 경관 계획을 위한 필수적인 종합 경관 정보를 제공하기 위해서, 경관 특성과 생물 다양성 가치 평가를 위한 생태 이질성 지수를 결합한 진보된 경관 특성 평가 방법론을 제시하는데 그 목적이 있다. 이 방법론을 통해 경관 특성 평가에서 12가지 경관 특성 유형(type)을 분류하였고 그것의 분포, 경관 특성적 형태, 경관 특성에 부정적인 영향을 줄 수 있는 개발 압력 등을 분석하고 서술하였다. 분석 결과, 주택과 산업 단지 개발, 농지 형질 패턴 변경, 수변 공간 개발 등이 주요 개발 압력으로 나타났다. 경관 생태 이질성 평가 결과에서는 도시 근교 지역과 농촌 경관 특성 유형 지역에서 잠재적 생물 다양성 가치가 높았다. 산림 지역 경관 특성 유형에서는 잠재적 생물 다양성 가치가 중간 수치로 나온 반면 도시 경관 특성 유형에서의 잠재적 생물 다양성 가치는 아주 낮았다. 비록 제한된 데이터와 경관 생태 이질성 지수 사용으로 인한 문제점들(스케일 종속적, 변화 패턴이 예측하기 힘든 지수, 자의적인 분류시 다른 결과 발생, 더 종합적인 생물 다양성 잠재력을 평가하기 위해서는 더 많은 다른 경관 생태 지수 필요 등)이 제기되었지만,

Corresponding author: Keun-Ho Kim, Namhwa Apartment 102-603, Hwajeong-dong, Seo-gu, Gwangju 502-240 South Korea, Tel: +82-62-361-1311, E-mail: manchester99@hanmail.net

이 연구에서 제시된 진보된 경관 특성 평가 방법론을 통해 얻은 종합적인 경관 정보가 지속가능한 경관계획을 할 때 어떻게 잘 활용되어질 수 있는지 예로써 증명하였다. 그 결과 진보된 경관 특성 평가 방법론이 지속가능한 경관 계획을 위한 수단으로 사용될 수 있을 것으로 사료된다.

Key words: Landscape Heterogeneity Index, Landscape Character, Landscape Assessment, Biodiversity

I. Introduction

One of the most important factors currently driving worldwide landscape change is urbanisation, and this can cause severe environmental problems such as air, soil and water pollution as well as the loss of biodiversity (Lawton, 1989; Ehrlich and Wilson, 1991; World Bank, 1992; White, 1994; Pivo, 1996; Rabinovitch, 1998; Lee *et al.*, 1999; Antrop, 2000; Goudie, 2000). South Korea is no exception. The South Korean population is expected to increase to 47 million by 2030 from 25 million in 1960, while the percentage of urban residents is expected to rise to more than 90% in 2030, compared with only 28% in 1960 (UN, 1998). As a consequence, urban areas have greatly expanded, leading to irreversible loss of agricultural land, a further degradation of air and water quality, as well as degradation of urban fringe landscapes, causing significant adverse effects on landscape character[1] and biodiversity (Cho, 2001). There is, therefore, an urgent need to deal with these environmental problems and to adopt policies for more sustainable urban landscape development, especially, in city regions. It is suggested that comprehensive landscape assessment for the whole territory of large urban regions is required to support this process.

In South Korea, landscape assessments are currently required as part of planning applications, but are limited to the visual impacts of developments as part of environmental impact assessments (EIA) (Yoo, 1997). Therefore, these assessments provide only a fragmentary picture of the landscapes within any local authority area. Moreover, the approach to nature conservation is also limited. In the first half of the 1990s, nature conservation was only concerned with the protection of ecologically important sites. This approach has been of limited success, as the reserves were often too small to provide for all of the habitat requirements of many species, such as foraging for animal species (OECD, 1997). Yet South Korea ratified the Convention on Biological Diversity in 1994, and the concept of ecological networks was formally introduced in South Korea in 1995 to protect and improve its ecosystems (OECD, 1997). Although South Korea's environmental policies are moving towards modern nature conservation, using principles of landscape ecology, it still lacks scientific information on landscape structure and function as a basis for developing spatial strategies for biodiversity conservation.

What methods and tools are suitable for providing the required information on landscape character and biodiversity in order to support planning for sustainability? Effective protection of the environment and the prudent use of natural resources are key objectives of sustainability (Swanwick and Land Use Consultants, 2002). These objectives can be achieved through sustainable landscape planning. It is suggested that landscape character assessment developed in the United Kingdom can be used as a tool for sustainable landscape planning because it provides comprehensive landscape information. It replaced previous very limited approaches to landscape assessment conserving the

natural beauty of the land and the public's enjoyment of it. The term 'landscape assessment' was first used in the 1980s, as a broad definition, encompassing the many different ways of looking at, describing, analysing and evaluating landscape (Swanwick, 1998; Makhzoumi and Pungetti, 1999). For instance, evaluating the landscape in terms of what makes one area 'different' or 'distinct' from another, as opposed to what makes one area 'better than another' (the 1970s view) (Swanwick and Land Use Consultants, 2002). However, these methods of landscape assessment pay little attention to the character of landscapes. Identifying and conserving the distinctive character of a landscape is important for long-term sustainability. Landscape character assessment considers that landscapes arise as the result of interactions between natural factors and human activities, and emphasises landscape character rather than landscape quality or value (Swanwick, 1998; Swanwick and Land Use Consultants, 2002). While it is believed that landscape character assessment can provide a suitable spatial framework for landscape character conservation strategies, it does not directly provide the detailed quantitative information on the ecology of landscapes, which is necessary for biodiversity conservation. This is an important issue in the study area, where urbansation is rapid and biodiversity is threatened by habitat loss and fragmentation.

Therefore, this paper suggests an advanced methodology of landscape character assessment by introducing quantitative measures of biodiversity potential. This paper introduces this methodology, presents the results, and discusses its potential as a useful tool for sustainable landscape planning to allow the effective protection of distinctive landscape character and biodiversity in Gwangju city region.

II. Methodology

1. Study Area

Gwangju city region was chosen for the study. The local authority covers 501 square kilometers and has a population of 1.4 million. Urban land use increased by 1,982 ha between 1995 and 2002. At the same period, the area of agricultural lands and woodlands dramatically decreased by 2,036 ha (Gwangju City, 2002). It is feared that these changes will result in a decrease of biodiversity and irreversible changes of landscape character and deterioration of environmental conditions.

2. Towards an Advanced Methodology

The methodology adopted for this study used standard landscape character assessment to identify distinctive landscape character units[2] and types[3], and to describe their key characteristics, as well as the main forces of change. This method was then complemented by calculating an index of landscape heterogeneity to provide information on the spatial ecological structure and to quantify the biodiversity potential in the study area. The methodology developed by this research consisted of five steps(Fig. 1).

Step 1: In this step, the background data was collected to provide a context and to prepare the necessary map analysis and data overlays for the first draft map of landscape character units and types. To delineate the first draft landscape character units and types, each of the natural (landform, water features, vegetation areas) and human features (built-up areas, agricultural land use patterns) was mapped using a set of criteria originally proposed by the Countryside Agency for the United Kingdom and adopted for this study. Single feature maps from the output of the first step were then overlaid and a draft character map was produced, delineating those areas which showed characteristic combinations of similar features.

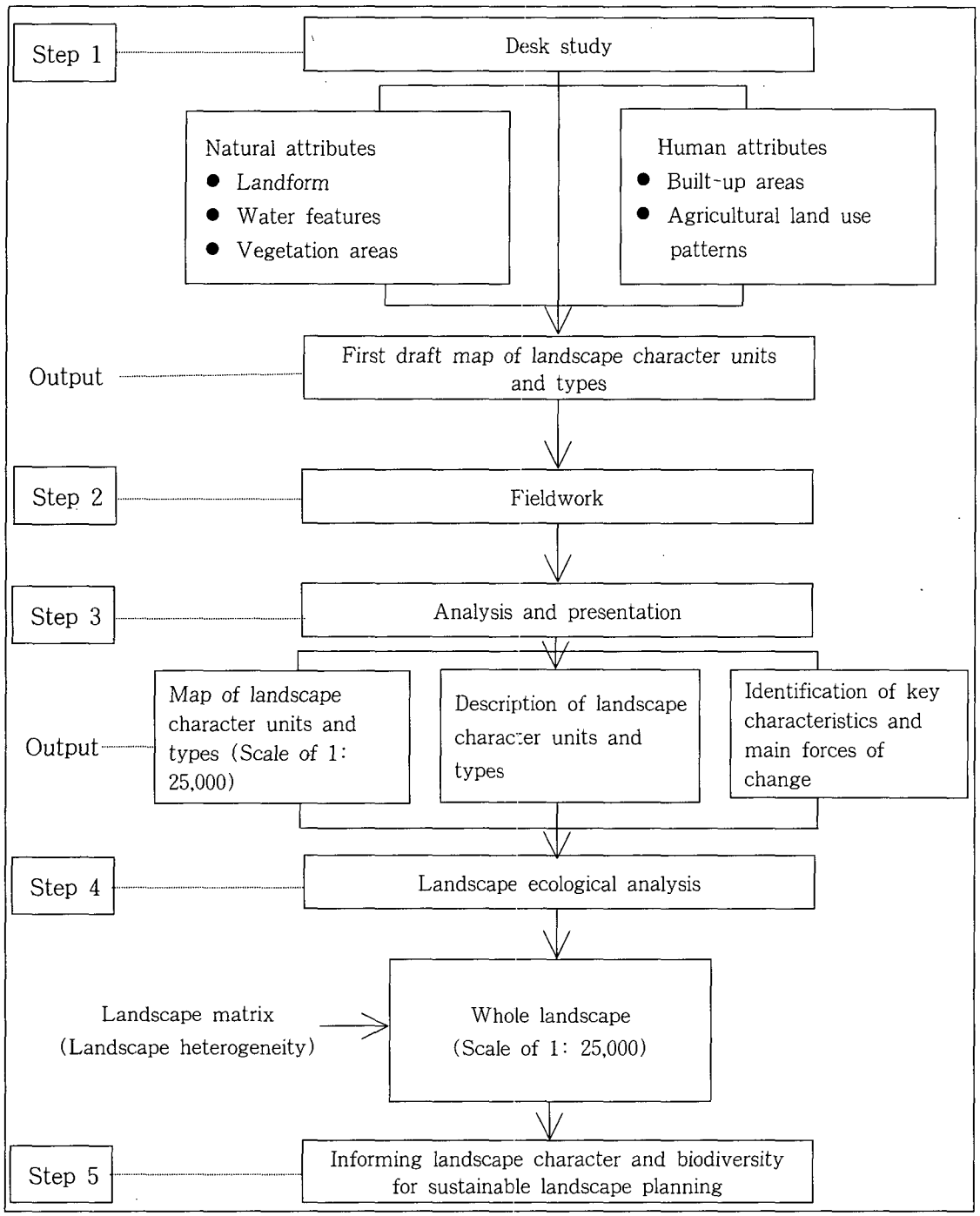

Fig. 1. Research steps.

Step 2: The aim of fieldwork was to verify and amend the draft landscape character units and types derived from the desk study, in order to modify errors, to provide descriptive information on the landscape

characters identified, to collect information on the aesthetic and perceptual aspects of the identified landscapes, and to inform subsequent analytical decisions. This study used photographs to document the landscape character units and types during fieldwork, but other cataloguing methods may well be suitable to summarise the characteristics of identified areas in a meaningful way.

Step 3: The third step was to bring together the findings from the desk study and the field survey and to present the results of the landscape character assessment at the city-regional level. For each of the landscape character types, the results included a list of their key characteristics and features, their distribution in Gwangju, a description of their physical characteristics and the main forces or pressures for change that may affect their character.

Step 4: The term biodiversity means different things to different people, such as a list of species, heterozygosity and a variety of species and vegetation (Lee *et al.*, 2004). As many ecologists and planners define the term of diversity, it means the abundance of each species or other entity (Noss, 1983). Forman and Godron(1986) suggested that the total species diversity is higher in heterogeneous landscapes that provide many ecosystem types. Although the reasons for this are far from clear, this is generally accepted by many authors, who emphasise the importance of using a quantitative approach to assess landscape heterogeneity as a measure for biological diversity (Odum, 1959; Hansson, 1977; Noss, 1983; Meentemeyer and Box, 1987; Forman, 1995; Sklenika and Lhota, 2002). Thus, this research assumed that landscape heterogeneity allows landscapes to maintain structure and ensure resilience and long-term sustainability. High heterogeneous landscape is taken to mean, in this study, more species diversity and more stability. To measure diversity of landscapes, there are several types of indices, such as a diversity index, a richness and an evenness index. Gwangju city did not have specific ecological data, such as vegetation types and coverage, for the whole case study area. Therefore, alternative methods were sought to indirectly estimate the biodiversity potential from alternative existing data sources. Thus, this research used the Shannon Diversity index (diversity index) as a surrogate measure for biodiversity potential because land cover data, such as land cover type, numbers and size of habitat patches obtained from maps and aerial photographs at the scale of 1:25,000. The formula it uses is:

$$SHDI = -\sum_{k=1}^{s} = PiInPi$$

where s = number of land cover types; Pi = proportion of area in land-cover k.

For land cover classification to measure biodiversity potential, three main classes and 13 sub-classes of land cover were distinguished (Table 1). The three main classes were urban land, agricultural land and semi-natural land. These were further subdivided into thirteen classes. The land cover types were based on a land use classification used in the study region, but modified to reflect the observed land cover.

This study concentrated mostly on the built-up areas, where a distinction was made between seven

Table 1. Land cover classification for measuring biodiversity potential

Level 1	Level 2
Urban land	Apartment blocks; Commercial land; Industrial land; Modern settlement; Traditional settlement; Managed open space; Unmanaged open space
Agricultural land	Arable land; Irregular rice field; Regular rice field
Semi-natural land	Reservoir; River; Woodland

urban types. Fewer categories were used for the surrounding countryside. As this study was particularly interested in the surrounding peri-urban landscapes, it was decided to reduce the overall number of land cover types to seven by combining the urban land cover categories into one.

III. Results

1. Landscape Character Assessment

The landscape character assessment of Gwangju distinguished 46 landscape character units on the basis of their particular combinations of natural and human features. These units were grouped into 12 landscape character types (Fig. 2).

Table 2 shows the general information collected for

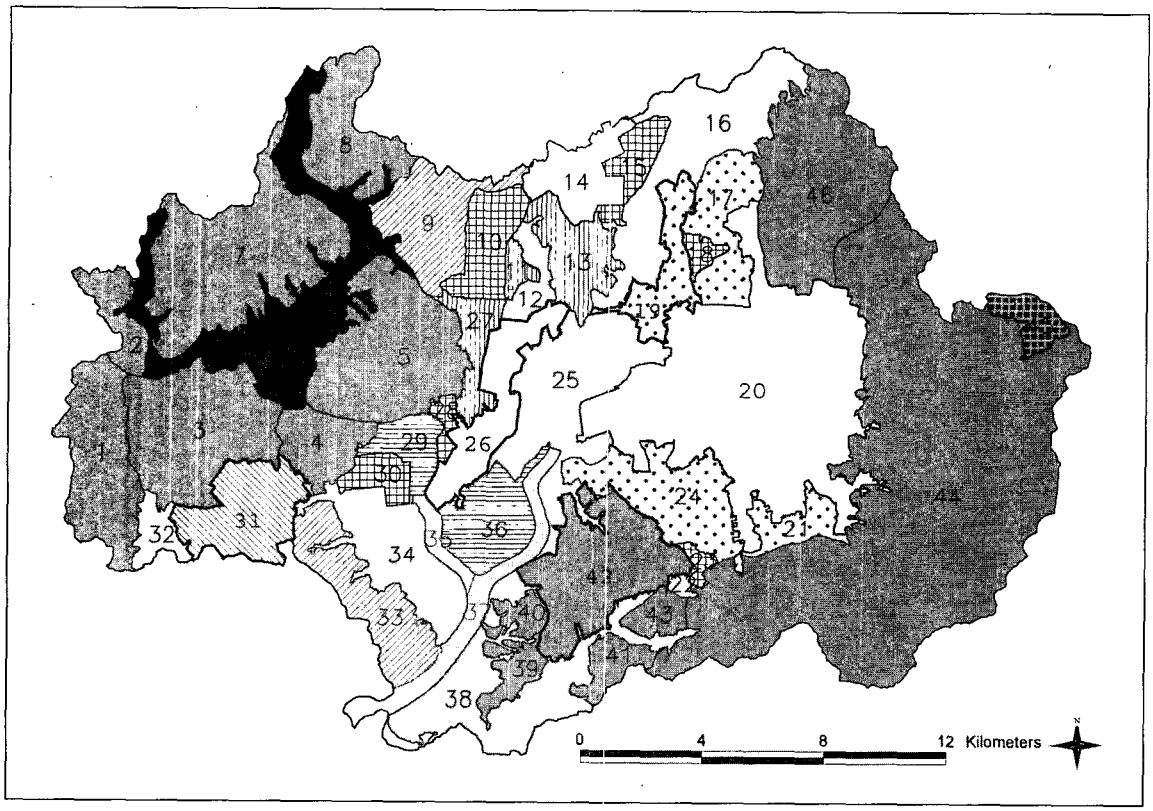

Fig. 2. Twelve landscape character types

Legend

Highlands:
- Natural wooded mountains
- Open valley regular rice fields
- Wooded irregular arable land

Lowlands:
- Core urban land
- Open arable land
- River basins
- Wooded arable land

Lowland Urban fringe:
- Industrial land
- Irregular arable land
- Open irregular rice fields
- Open regular rice fields
- Wooded irregular arable land

1-46 Number of character unit

Table 2. Landscape character types in Gwangju

Landscape character types	No. of landscape character units	Overall area (ha)	% of total area	Key characteristics
No. 1: Highland natural wooded mountains	14	23,337	46.6	Large scale, natural undulating physical landforms; Terraced small scale arable lands along valley bottoms; Unplanned old villages with little development
No. 2: Highland open valley regular rice fields	1	2,275	4.5	Modern open flat rice fields along rivers; Unstructured settlement patterns in the middle of rice fields
No. 3: Highland wooded irregular arable land	1	300	0.6	An elevated undulating landform; Unspoiled landscapes with small scale irregular agricultural patterns responding to the natural landforms; Traditional settlements with many historical features and little development
No. 4: Lowland core urban land	3	6,551	13.1	An open, flat and monotonous landform; Intensive modern settlements in a grid pattern; Massive road networks
No. 5: Lowland open arable land	1	1,014	2.0	Open gently slopping landforms; Irregular mixed agricultural fields surrounded by low wooded mountains; Isolated old settlements with little development
No. 6: Lowland river basins	2	882	1.8	A flat, open, relatively regular arable field along rivers; Semi-natural vegetation and riparian habitats
No. 7: Lowland urban fringe industrial land	6	1,502	3.0	A large, flat, open landform with little vegetation cover; Large scale highly visible industrial developments
No. 8: Lowland urban fringe wooded irregular arable land	3	1,223	2.4	Irregular, gently slopping arable fields surrounded by woodlands; Modern settlement developments expand existing traditional settlements; Mixed land uses
No. 9: Lowland urban fringe open irregular rice fields	7	6,943	13.9	Open, flat irregular mixed agricultural fields; Rice fields converted into massive modern vinyl greenhouses; Scattered settlements in the middle or at the edge of rice fields
No. 10: Lowland urban fringe open regular rice fields	4	2,866	5.7	Modern, open regular rice fields; Little tree cover
No. 11: Lowland urban fringe irregular arable land	2	2,032	4.1	Irregular terraced arable fields surrounded by woodlands; High rise apartments in urban fringe areas
No. 12: Lowland wooded arable land	2	1,182	2.3	A gently sloping landform; Enclosed irregular arable fields; Scattered settlements with little development
Total	46	50,107	100.0	

the 12 landscape character types. Wooded mountains (Landscape character type No. 1) located in the east and west of the study area are the single largest character type with 47% of the total area, followed by urban fringe areas characterised by irregular rice fields (No. 9). The urban character type covered 13% of the study area. Although the number of individual units for landscape character type No. 7 (Urban fringe with industrial land) was as high as 7, this type covered just 3% of the total area. The other landscape character types were only represented by a few units and covered small areas.

The main forces of change observed in the whole study area were urban developments such as housing and industry, modification of field patterns and riverfront recreation developments. In the case of landscape character types Nos. 4, 7, 8, 9 and 11, the most profound change was housing and industrial development. Over one million people live in these landscape types and generate increasing demands for transport, jobs, water supply and housing. Demographic and household changes over the last decade have led to an increased demand for additional dwellings. A need to improve the quality of the road infrastructure is recognised as a key requirement for economic development in the study area. Its implementation would lead to further development of new housing and roads and increase the pressure on greenspace in the character type No. 4. The landscape character types Nos. 7, 8, 9 and 11, which are located on the edge of the urban core areas, have also been under increased pressure from new developments. Woodlands and arable lands adjacent to urban areas were particularly under pressure from developments, such as massive apartment blocks and business parks, the construction of major roads, as well as the extension of public transport infrastructure. These developments have a strong impact on landscape character.

In the case of landscape character types Nos. 5, 9, 10 and 12, the main force of change was the modification of field patterns. Korean traditional agricultural landscapes were characterised by irregular small fields and surrounded by small scale woodlands. However, modern agricultural policies designed to increase agricultural productivity have changed traditional field patterns into large scale field patterns. This has led to the removal of woodlands.

The research found that the main force of change was riverfront and tourist developments in the landscape character types Nos. 1, 2, 3, 5 and 6. The potential to change and improve the terraced agricultural land and intensify its use was limited in the highland landscape character types such as Nos. 1 and 3. The most profound change in these types has been tourist development. Although these landscape character types are one of the least changed within the study area, there are development pressures these days. Especially, the low mountains are particularly exposed to new building developments on the edge of the mountains. At present, this development is restricted to some extent, because, historically, Gwangju controls the developments by designating all mountain areas as greenbelt. However, there are increasing pressures to construct larger tourist hotel developments as well as new roads. The highland landscape character types are especially vulnerable to any new development proposals, particularly around Gwangju Lake and the historic estates. With the increased demand for water recreation activities, there have been waterfront development pressures in the landscape character types Nos. 2, 5 and 6 in the study area. The field survey identified few signs of change in the landscape type No. 5, except around the reservoirs due to the increased demand for water recreation. In the case of landscape character types Nos. 2 and 6, the extraction of sand and gravel from the Youngsan and Hwangrong Rivers, to regulate the

rivers flow and for use as a construction material in the past, has destroyed an undisturbed landscape. Other changes around the rivers include road improvements and bridge construction. Generally, however, they have seen little recent change and are less likely to be subjected to development pressures, in comparison with other landscape character types. However, as the Gwangju axis of urban development moves to the west, there are more pressures for waterfront developments, such as waterfront parks and riverbed uses along the Youngsan and Hwangrong Rivers.

Fig. 3 shows the different land cover types which dominated and influenced each landscape character type. Landscape character types Nos. 4 and 7 were dominated by urban land cover, modern settlement and industrial land, with more than 80% of each respectively. In the case of landscape character types Nos. 1 and 11, one land cover type, woodland, was the dominant land cover type, with a cover of more than 50% of the surface area. These woodlands mostly consisted of pine (*Pinus densiflora* and *Pinus rigida*), alder (*Alnus japonica*) and oak (*Quercus acutissima*). Most woodlands were larger than 5ha and well connected. The second most abundant land cover type was arable land and irregular rice field land for the two landscape types respectively.

In landscape character types Nos. 5, 8, 9, 10 and 12, agricultural land was the dominant land cover type with more than 60 % of the total area. Semi-natural land such as woodland was the second most important land cover type in these landscape character types. These woodlands were differentiated from those found in the highland mountains. Woodlands in these land-

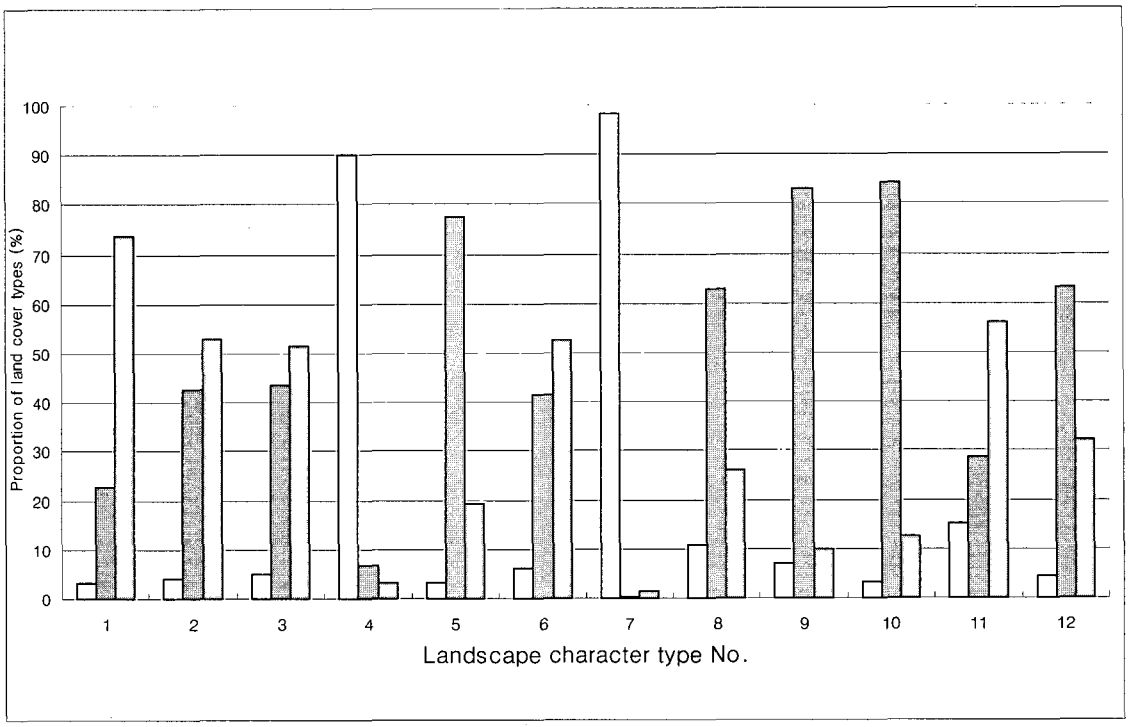

Fig. 3. Proportions of land cover in the 12 landscape character types.
Legend: Urban land. Agricultural land. Semi-natural land

scape character types mainly consisted of the pine community (*Pinus densiflora*). Most of the smaller sized woodlands (less than 1 ha) were scattered in the areas, and these small distributions of woodland with irregular arable land created a unique landscape type. Agricultural (Nos. 5, 10 and 12) and urbanised (Nos. 8 and 9) activities have dissected the woodland habitats for many plant and animal species into small isolated patches. Finally, a rich mix of agricultural and semi-natural land patches was present in landscape character types Nos. 2, 3 and 6.

2. Index of Landscape Heterogeneity

Fig. 4 shows the results of landscape heterogeneity for the 46 landscape character units. Landscape character units Nos. 31 (value = 1.55), 27 (1.51), 33 (1.48), 19 (1.48) and 9 (1.48) had the highest values of landscape heterogeneity. Units Nos. 31, 27, 33 and 9 were rural areas with agricultural land cover of over 60% and semi-natural land cover of approximately 20% of the total area. In landscape character type No 19, semi-natural areas covered more than 40% of the land and urban land covered 31% of the total area.

Landscape character units with high values of heterogeneity were mostly found in the rural and urban fringe areas. This was the case, for instance, for landscape character units Nos. 31 (1.55), 33 (1.48), 9 (1.48), and 45 (1.47) in the agricultural areas, and Nos. 27 (1.51) and 19 (1.48) in the urban fringe areas,

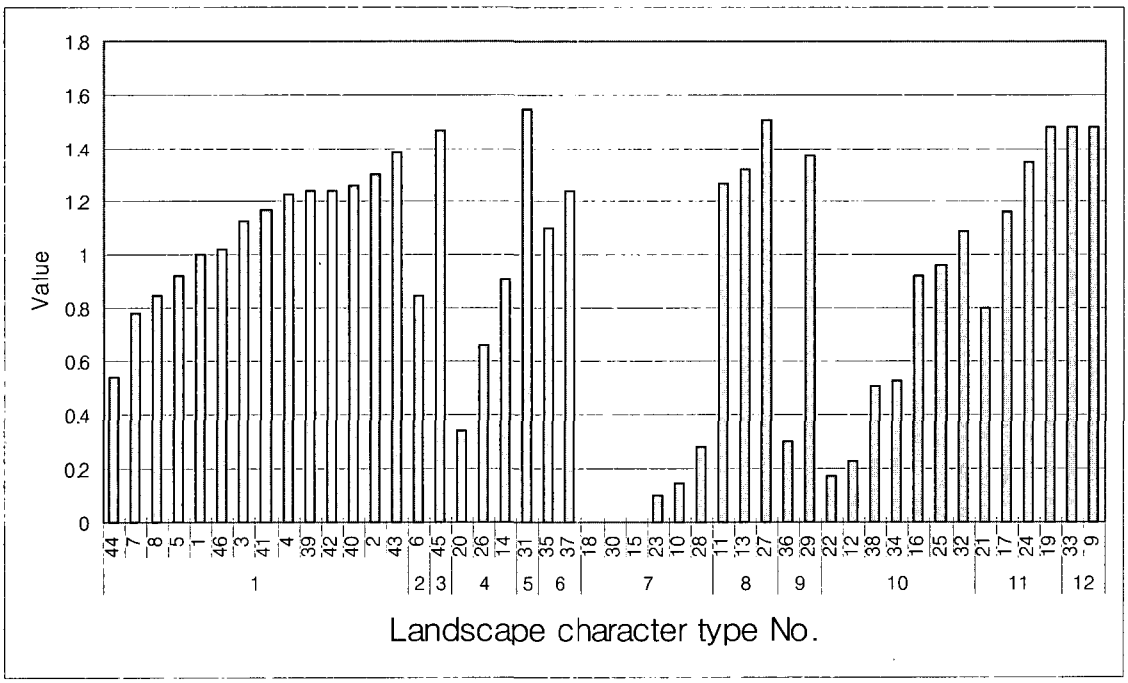

Fig. 4. Value of landscape heterogeneity for the 46 landscape character units.

Legend

No. 1: Highland natural wooded mountains
No. 2: Highland open valley regular rice fields
No. 3: Highland wooded irregular arable land
No. 4: Lowland core urban land
No. 5: Lowland open arable land
No. 6: Lowland river basins
No. 7: Lowland urban fringe industrial land
No. 8: Lowland urban fringe irregular arable land
No. 9: Lowland urban fringe open irregular rice fields
No. 10: Lowland urban fringe open regular rice fields
No. 11: Lowland urban fringe wooded irregular arable land
No. 12: Lowland wooded arable land

with a mix of different land cover types. In contrast, landscape character units, such as Nos. 15, 18, 30, 23 and 10 had low values of landscape heterogeneity in the study area. In these landscape character units, one land cover type predominated. For instance, urban land had a surface cover of more than 90% in landscape character units Nos. 15, 18, 23 and 30, whereas regular fields covered more than 90% of the surface area in character units Nos. 22 and 28.

The index of landscape heterogeneity showed that the 12 landscape character types had different heterogeneity values (Fig. 5). Three broad groups of landscape character types were distinguished in terms of heterogeneity. Firstly, landscape character types had a relatively high heterogeneity value in the rural (Nos. 5, 12, 3 and 6) and urban fringe areas (Nos. 8 and 11), where semi-natural and agricultural land cover together was predominant (Table 3). Secondly, landscape character types Nos. 1 (0.94), 9 (0.87), 2 (0.85) and 10 (0.80) had intermediate values of the heterogeneity index. Human dominated agricultural land patches (regular rice fields) predominated in landscape character types Nos. 2, 9 and 10, and semi-natural land cover patches predominated in landscape character type No.1. Thirdly, landscape character types Nos. 4 (0.48) and 7 (0.1) had low values of landscape

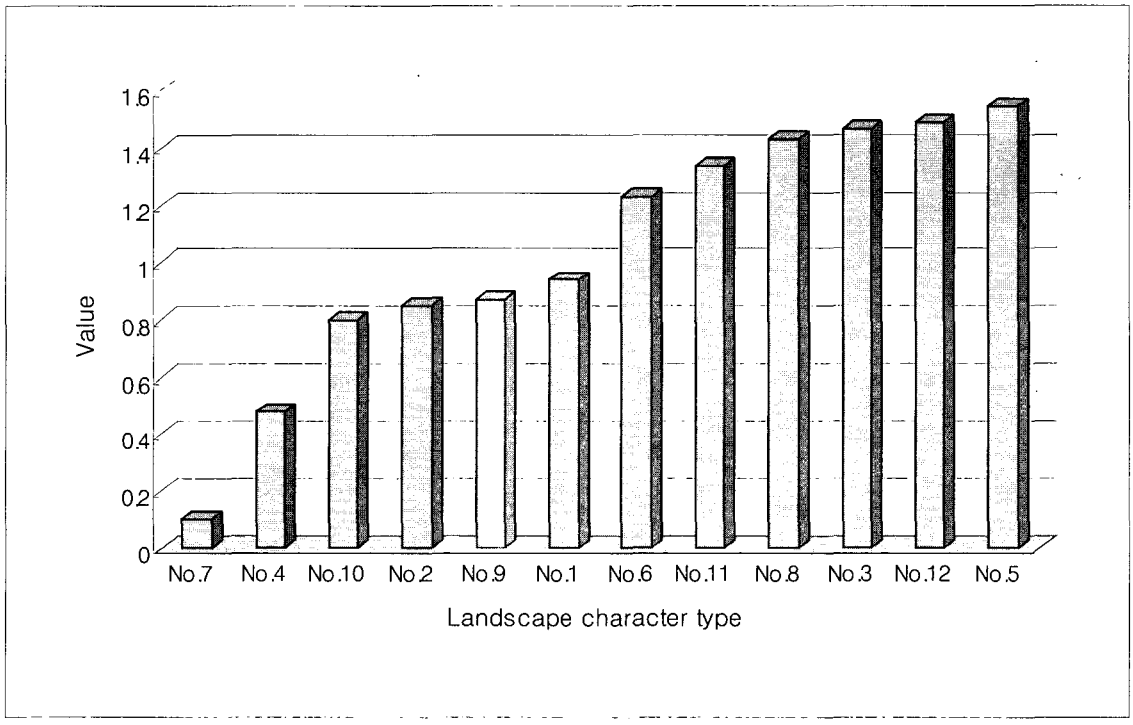

Fig. 5. Value of landscape heterogeneity for the 12 landscape character types in the study area.

Legend

No. 1: Highland natural wooded mountains
No. 2: Highland open valley regular rice fields
No. 3: Highland wooded irregular arable land
No. 4: Lowland core urban land
No. 5: Lowland open arable land
No. 6: Lowland river basins
No. 7: Lowland urban fringe industrial land
No. 8: Lowland urban fringe irregular arable land
No. 9: Lowland urban fringe open irregular rice fields
No. 10: Lowland urban fringe open regular rice fields
No. 11: Lowland urban fringe wooded irregular arable land
No. 12: Lowland wooded arable land

Table 3. Proportions of the 7 main land cover types and the values of landscape heterogeneity in the 12 landscape character types of the study area

Landscape character type No.	Proportion of land cover types (%)								Index of heterogeneity
	Urban land	Agricultural land			Semi-natural land			Total	
	Urban land	Arable land	Irregular rice land	Regular rice land	Reservoir	River	Woodland		
1: Highland natural wooded mountains	3.32	11.97	10.16	0.73	1.14	0.46	72.22	100	0.94
2: Highland open valley regular rice fields	1.45	1.84	5.39	74.21	0.02	15.96	1.13	100	0.85
3: Highland wooded irregular arable land	4.87	13.99	29.67	0.00	20.48	0.00	30.99	100	1.47
4: Lowland core urban land	90.07	3.94	1.24	1.54	0.28	1.27	1.66	100	0.48
5: Lowland open arable land	3.19	41.50	19.88	15.99	5.49	0.96	12.99	100	1.55
6: Lowland river basins	6.00	8.40	27.18	5.90	0.00	52.52	0.00	100	1.23
7: Lowland urban fringe industrial land	98.29	0.19	0.00	0.00	0.59	0.38	0.55	100	0.10
8: Lowland urban fringe wooded irregular arable land	10.96	43.61	17.02	2.27	1.37	0.78	23.99	100	1.43
9: Lowland urban fringe open irregular rice fields	7.08	6.58	75.68	0.76	0.66	9.07	0.17	100	0.87
10: Lowland urban fringe open regular rice fields	3.18	4.30	1.71	78.33	0.09	11.25	1.14	100	0.80
11: Lowland urban fringe irregular arable land	15.20	17.41	8.21	2.98	1.08	1.49	53.63	100	1.34
12: Lowland wooded arable land	4.48	35.07	19.93	8.23	1.51	0.66	30.12	100	1.49

heterogeneity. A single land cover type (urban land cover) strongly predominated in these landscape character types. Thus, the rural and urban fringe landscapes were likely to have a higher value than the urban landscapes.

Ⅳ. Discussion and Conclusion

In this paper, landscape character assessment, developed and widely used in the United Kingdom, has been further developed and applied to a study of the Gwangju city. In other studies carried out elsewhere, such as in England and Hong Kong, the methods of analysis were based on just one aspect of landscape, landscape character, while Germany and the United States have used more ecologically based approaches (McHarg, 1969; Haber, 1990; Bastian and Rder, 1998; Countryside Agency and Scottish Natural Heritage, 1999; Steiner, 1999; Planning Department, 2001a; 2001b; Swanwick and Land Use Consultants, 2002; German Federal Agency for Nature Conservation, undated). In that sense, this study offers a perspective suggesting how landscape character assessment can be further developed to provide the ecological information required for sustainable landscape planning.

The landscape character assessment of Gwangju identified 46 landscape character units. These 46 landscape character units were then classified into 12

landscape character types. This study elucidated key characteristic features and the main forces of change of adverse effect on landscape character (see Table 2). The index of landscape heterogeneity derived from land cover data was calculated to quantify biodiversity potential and different values were observed between landscape character types. From the results of this study, it is concluded that an advanced methodology of landscape character assessment offers the potential for use as a tool in sustainable landscape planning, aimed towards the effective protection of the environment and the prudent use of natural resources. The reason is that it provides more comprehensive information on landscapes to assist policy makers to protect and enhance the landscape character and the ecological conditions. The following section attempts to demonstrate how this tool can be used to identify the specific needs for sustainable landscape planning in different landscape character types. To do this, this section summarises the three landscape character types as examples.

Firstly, in the case of landscape character type No. 4 (the urban landscape), this landscape was characterised by an open, flat and monotonous landform and dominated by intensive modern residential and commercial land cover in a grid pattern. Future urban developments, such as more construction for housing and infrastructure, are likely to have a further negative impacts on the landscape character and ecological condition of this landscape type. The value for the index of landscape heterogeneity was the lowest in the study area. For sustainable landscape planning to provide effective protection of the landscape character and increase biodiversity, there is a need to strictly protect the natural landscape elements and introduce more natural land cover types to enhance both the landscape character and ecological conditions in this landscape type. The role of cities as a habitat for wildlife has been increasingly recognized in other parts of the world (Vh-Piikki *et al.*, 2004). However, Gwangju City is a very densely built-up urban area, and greenspace covers only small areas. It is intensively used and managed as islands within the urban fabric. Therefore, it is suggested that the low biodiversity value accurately reflects the biodiversity potential of Gwangju city. Preservation of the semi-natural land cover that is left in urban areas, and provision of more greenspace, are required for improving the landscape character and biodiversity potential of the urban landscape. Singapore, where great efforts have been undertaken to introduce a coherent greenspace network, could provide an example of how this can be achieved in densely built-up urban areas in an Asian context (Briffe, 2001; Ong, 2003).

Secondly, in the case of landscape character type No. 5 (the agricultural landscape), this landscape dominated by agricultural land cover types was characterised by an open gently sloping landform and an open irregular terraced arable field at the edges of the mountain areas. A modification of arable field patterns and demands for water recreation and waterfront developments have had adverse effects on this landscape character. In this landscape, protection of natural landscape features, such as natural land forms, and cultural features, such as traditional field patterns and reservoirs, is required. This landscape character type had intermediary values of landscape heterogeneity. While the habitat value of paddy rice fields in these landscapes will be low due to modern farming practices, they still contain a certain amount of semi-natural land cover such as woodlands and water surfaces. However, the woodlands are often fragmented and subject to disturbance from surrounding fields. Increasing the cover and size of woodlands, and establishment of habitat corridors between the woodlands and less intensive farming on the surrounding fields, would be important tasks to improve the eco-

logical conditions in these landscapes.

Thirdly, in the case of landscape character type No. 11 (the urban fringe landscape), this landscape was characterised by irregular and enclosed, small to medium-scale terraced arable fields often bordered by woodlands and some high rise modern settlements at the edge of core urban area. Both housing expansion from adjoining urban areas and a conversion of woodlands and arable fields into urban land uses have had an adverse effect on this landscape character. The effect of land cover changes is likely to result in the loss of distinctive urban fringe landscape character and make the urban fringe landscape more monotonous like urban landscapes. This landscape had the highest values of landscape heterogeneity. The biodiversity potential may still be high but due to the rapid landscape change in particular, woodlands are lost and the remaining woodlands are becoming increasingly isolated. The index value does not capture these dynamics, as it is only based on data from one particular point in time. However, this landscape character type was the most dynamic landscapes in the study area. In particular, woodlands and other semi-natural land covers, which are amongst the most important for biodiversity, are under strong pressure from urban developments. Therefore, a programme needs to be made to preserve the features that provide ecological stability to urban fringe landscapes, such as the woodlands. It is suggested that their preservation should be complemented by the development of habitat corridors to enhance species dispersal between otherwise isolated habitats.

Despite its success this study has some the limitations. This research suggests further work to be carried out to develop a better methodology of landscape character assessment. Firstly, some problems can be noted in classifying the landscape character units and types. In particular, there is a lack of information to complete a better landscape character assessment at present. Some factors such as geology, soils and historical dimensions of a landscape are needed to provide more information on the characteristics of landscape and an understanding of the whole landscape.

Secondly, the particular challenge here is that information on habitats and wildlife is still very limited in the study area. Therefore, in this study an indirect method had to be devised using land cover data. It does not directly provide information on the quality of these surfaces, for instance as a habitat (vegetation types, species composition and numbers, rare and endangered species). Land cover may look similar in different landscape character units and types, but its quality may be very different due to the specific combination of ecological factors (e.g. geology, soils and climate), land management and history. Therefore, it should be validated where possible by data from habitat and wildlife surveys.

Thirdly, the index of landscape heterogeneity did not capture the importance of the mountain landscape. These areas are rather homogeneously covered by woodlands. Therefore, the value of landscape heterogeneity was comparatively low. However, these woodlands are generally considered as the most important areas for biodiversity conservation in South Korea (OECD, 1997), because they include a range of different woodland types with habitats for specialized woodland species. Therefore, using the index of landscape heterogeneity alone is of limited value, and more detailed knowledge on the different types of landscape analysed is required to understand what the indicator actually means. The index of landscape heterogeneity may be of limited value for comparison across landscape types. Rather, it may be more suitable for comparison between landscape character types of the same landscape types, and it can be of more value in monitoring landscape change (Antrop and Eetvelde, 2000; Sklenika and Lhota, 2002). In other words, once

established, landscape character and ecological quantitative data can enable the generation of new information for the comparative evaluation of alternatives.

Fourthly, the index of landscape heterogeneity is also scale dependent and sensitive to criteria used for land cover classification. For instance, the urban landscape types appeared to be rather homogeneous at the broad scale of this study, but they may be highly heterogeneous, due to a diversity of different land uses and spatial structures, when looked at in more detail. Furthermore, many studies indicate that landscape metrics are sensitive to criteria used for land cover classification (Gustafson, 1998; Li and Wu, 2004; Wickham *et al.*, 1997). For instance, the Shannon Diversity index is sensitive to the number of different land cover types and the proportional distribution of the area among patch types. This index increases as the number of different land cover types increases. A high number of seven land cover types were distinguished in urban areas whereas only three types were distinguished in agricultural and semi-natural areas respectively in this study. Thus, urban landscapes have a high value of landscape heterogeneity due to the variety of urban land cover types. This problem raises the question of how many land cover types should be distinguished to predict the degree of biodiversity? To rather accurately reflect biodiversity potential, this study was decided to reduce the overall number of land cover types to seven by combining the urban land cover categories into one. Thus, classifying land cover types was somewhat arbitrary. Previous studies clearly show that the most important source of error is misclassification and error in metrics are not greater that data error itself (Wickham *et al.*, 1997). Systematic methods such as Normalized Difference Vegetation Index, Vegetation Index, Ratio Vegetation Index are suggested to minimize misclassification (Elvidge and Chen, 1995; Johnston, 2001).

Fifthly, the index of landscape heterogeneity measured a dimension of landscape composition. However, landscape ecology stresses the importance of the spatial configuration of landscapes. For example, species dispersal is enhanced in a landscape when suitable habitats such as woodlands in the study area are closely neighbored (Opdam *et al.*, 1993). A variety of landscape ecological metrics have been suggested to assess various aspects of landscape configuration, such as patch distance, patch shape and patch context, that provide a more complete picture of the biodiversity potential of the different landscape types (Romme, 1982; Forman *et al.*, 1986; O'Neill *et al.*, 1988; Turner, 1989; Baker and Cai, 1992; Forman, 1995; McGarigal and Marks, 1995; Hargis *et al.*, 1998; Gustafson, 1998; Cook, 2002). Taken together, these landscape metrics may then provide yet more valuable information for sustainable landscape planning, to make proposals for key habitats to be conserved, necessary (re-)establishment of further habitats and the development of habitat corridors.

Finally, the approach presented here can only be considered as a first step towards a more comprehensive landscape analysis for sustainable landscape planning. Having acknowledged the limitations of this study, the results suggest that landscape character assessment has considerable potential to be used as a tool for sustainable landscape planning to protect landscape character and biodiversity. While the approach was tested in one particular South Korean city region, Gwangju city, the method developed is argued to be generic and therefore should also be applicable to other city regions in South Korea, and indeed elsewhere.

Acknowledgements

I would like to sincerely thank Stephan Pauleit, Roger Bristow, School of Planning and Landscape, The University of Manchester, for all their help to supervise

the study and improve this paper.

Annotation 1. A distinct and recognisable pattern of elements that occur consistently in a particular type of landscape. Particular combinations of geology, landform, soils, vegetation, land use, field patterns and human settlement create character.

Annotation 2. Landscapes with broadly similar patterns of geology, soils, vegetation, land use, settlement and field patterns. Landscapes belonging to a particular type - for example an 'Upper Dale' landscape - may be found in many different places.

Annotation 3. Unique types - geographically discrete examples of a particular landscape unit. For example 'Upper Teesdale' is a character type belonging to the 'Upper Dale' type.

References

1. Antrop, M.(2000) Changing patterns in the urbanized countryside of Western Europe. Landscape Ecology 15: 257-270.
2. Antrop, M. and V. V. Eetvelde(2000) Holistic aspects of suburban landscapes: visual image interpretation and landscape metrics. Landscape and Urban Planning 50: 43-58.
3. Baker, W. L. and Y. Cai(1992) The r.le programs for multiscale analysis of landscape structure using the GRASS geographical information system. Landscape and Ecology 7(4): 291-302.
4. Bastian, O. and M. Rder(1998) Assessment of landscape change by land evaluation of past and present situation. Landscape and Urban Planning 41: 171-182.
5. Briffett, C.(2001) Is managed recreational use compatible with effective habitat and wildlife occurrence in urban open space corridor systems? Landscape Research 26(2): 137-163.
6. Cho, H. J.(2001) Urban forest landscape. In C. S. Lee, H. H. Won, and J. S. Song, eds., Landscape Ecology. Seoul: Dong Hwa. pp. 339-358.
7. Cook, E. A.(2002) Landscape structure indices for assessing urban ecological networks. Landscape and Urban Planning 58: 269-280.
8. Countryside Agency and Scottish Natural Heritage(1999) Interim Landscape Character Assessment: Guidance for England and Scotland. London: Land Use Consultants.
9. Ehrlich, P. R. and E. O. Wilson(1991) Biodiversity studies: science and policy. Science 253: 758-762.
10. Elvidge, C. D. and Z. Chen(1995) Comparison of broad-band and narrow-ban red and near-infrared vegetation index. Remote Sensing of Environment 54: 35-48.
11. Forman, R. T. T.(1995) Land Mosaics: The Ecology of Landscape and Regions. Cambridge: Cambridge University Press.
12. Forman, R. T. T. and M. Godron(1986) Landscape Ecology. New York: John Wiley & Sons.
13. German Federal Agency for Nature Conservation (BfN). undated. Landscape Planning for Sustainable Municipal Development. Brochure, Bonn, Germany.
14. Goudie, A.(2000) The Human Impact on the Natural Environment. Oxford: Blackwell.
15. Gustafson, E. J.(1998) Quantifying landscape spatial pattern: what is the state of the art. Ecosystems 1: 143-156.
16. Gwangju City(2002) Gwangju in Statistics. Gwangju: Gwangju City.
17. Haber, W.(1990) Using landscape ecology in planning and management. In I. S. Zooneveld and R. T. T. Forman, eds., Changing Landscapes: An Ecological Perspective. New York: Springer-Verlag. pp. 217-231.
18. Hansson, L.(1977) Landscape ecology and stability of population. Landscape Planning 4: 85-93.
19. Hargis, C. D., J. A. Bissonette, and J. L. David(1998) The behavior of landscape metrics commonly used in the study of habitat fragmentation. Landscape Ecology 13: 167-186.
20. Johnston, C. A.(2001) Methods in Ecology: Geographic Information Systems in Ecology, Malden, MA: Blackwell Science.
21. Lawton, R.(1989) The Rise and Fall of Great Cities. London: Belhaven.
22. Lee, J. T., M. J. Elton, and S. Thompson(1999) The role of GIS in landscape assessment: using land-use-based criteria for an area of the Chiltern Hills Area of Outstanding Natural Beauty. Landscape Ecology 16: 23-32.
23. Lee, S. W., E. J. Yoon, and I. S. Lee(2004) Review of issues and problems in using landscape ecology indices. Journal of the Korean Institute of Landscape Architecture 32: 73-83.
24. Li, H. and J. Wu(2004) Use and misuse of landscape indices. Landscape Ecology 19: 389-399.
25. Makhzoumi, J. and G. Pungetti(1999) Ecological Landscape Design and Planning. London: E & FN SPON.
26. McGarigal, K. and B. J. Marks(1995) FRAGSTATS: Spatial Pattern Analysis Program for Quantifying Landscape Structure. USDA Forest Service, Technical Report, PNW-351.
27. McHarg, I.(1969) Design with Nature. New York: History Press.
28. Meentemeyer, V. and E. O. Box(1987) Scale effects in landscape studies. In M. G. Turner, ed., Landscape Heterogeneity and Disturbance. New York: Springer-Verlag. pp. 15-34.
29. Noss, R. F.(1983) A regional landscape approach to maintain diversity. BioScience 33: 700-706.
30. Odum, E. P.(1959) Fundamentals of Ecology. Pennsylvania: W.B. Philadelphia.
31. O'Neill, R. V., J. R. Krummel, G. Gardner, B. Sugihara, D. L. Jackson, B. T. DeAngelis, M. G. Milne, B. Turner, S. W. Zygmunt, V. H. Christensen, and R. L. Graham(1988)

Indices of landscape pattern. Landscape Ecology 1: 153-162.
32. Ong, B. L.(2003) Green plot ratio: An ecological measure for architecture and urban planning. Landscape and Urban Planning 63: 197-211.
33. Opdam, P., R. van Apeldoorn, A. Schotman, and J. Kalkhoven(1993) Population responses to landscape fragmentation. In C. C. Vos and P. Opdam, eds., Landscape Ecology of a Stressed Environment. London: Chapman and Hall. pp. 96-108.
34. Organisation for Economic Co-operation and Development (1997) Environmental Performance Reviews-Korea. Paris: OECD.
35. Pivo, G.(1996) Toward sustainable urbanization on mainstreet Cascadia. Cities 13(5): 339-354.
36. Planning Department(2001a) Landscape Value Mapping of Hong Kong: Inception Report. Hong Kong: Government Information Services.
37. Planning Department(2001b) Landscape Value Mapping of Hong Kong: Technical Report No. 1. Hong Kong: Government Information Services.
38. Rabinovitch, J.(1998) Global, Regional and Local Perspectives Towards Sustainable Urban and Rural Development. In E. Fernandes, ed., Environmental Strategies for Sustainable Development in Urban Areas: Lessons from Africa and Latin America. Alershot: Ashgate. pp. 16-44.
39. Romme, V. H.(1982) Fire and landscape diversity in subalpine forests of Yellowstone National Park. Ecological Monographs 52: 199-221.
40. Sklenika, P. and T. Lhota(2002) Landscape heterogeneity: a quantitative criterion for landscape reconstruction. Landscape and Urban Planning 58: 147-156.
41. Steiner, F.(1999) The Living Landscape. New York: McGraw-Hill.
42. Swanwick, C.(1998) New forces for change. Landscape Design April: 8-11.
43. Wanwick, C. and Land Use Consultants(2002) Landscape Character Assessment: Guidance for England and Scotland. Countryside Agency, Cheltenham and Scottish Natural Heritage.
44. Turner, M. G.(1989) Landscape ecology: the effect of pattern on process. Annual Review of Ecology and Systematics 20: 171-197.
45. United Nations(1998) World Urbanization Prospects: The 1996 Revision. New York: United Nations.
46. Vh-Piikki, I., A. Kurtto, and V. Hahkala(2004) Species number, historical elements and protection of threatened plants in Helsinki, Finland. Landscape and Urban Planning 68: 357-370.
47. White, R. R.(1994) Urban Environmental Management. Chichester: John Wiley & Sons.
48. Wickham, J. D., R. V. O'Neill, K. H. Ritters, T. G. Wade, and K. B. Jones(1997) Sensitivity of landscape pattern metrics to land cover misclassification and differences in land-cover composition. Photogrammetric Engineering and Remote Sensing 63: 397-402.
49. World Bank(1992) World Development Report 1992. Oxford: Oxford University Press.
50. Yoo, J. C.(1997) An Analysis of the Environmental Impact Assessment System in South Korea. MA. Dissertation. University of Manchester, Manchester.

원 고 접 수: 2005년 4월 11일
최종수정본 접수: 2005년 6월 20일
3인익명 심사필