Characteristics of woodland changes in an urban fringe in Gwangju city

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도시외곽지역의 산림변화 특성

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Abstract : It is widely recognised that changes in size and isolation of habitat patches have a negative impact on species richness and the distribution and persistence of populations. Thus, the aim of the research was to analyze the change, distribution and spatial characteristics of woodlands in an urban fringe landscape. The results indicated that there was a common trend of woodland loss across all landscape types while no new woodlands were established during 1976 and 2009. Small patches (less than 5 ha in size) were particularly vulnerable to and more likely to disappear due to human activities such as urbanisation. Changes in woodland cover were clearly observed between 1976 and 2009. Loss of many woodlands was caused by residential and infrastructural developments. As a result, woodlands were becoming smaller and more isolated. This trend probably had adverse effects on biodiversity. This woodland information can be used to identify the potential and specific needs for conservation planning in rapidly developing urban areas.

Key words **:** Biodiversity, Landscape change, Urban fringe landscape, Woodland

I. Introduction

Current landscape changes are particularly strong in urban fringe landscapes of rapidly developing urban regions (Pirnat, 2000; Antrop, 2004). Urbanization has been caused landscape changes and resulted in the loss of habitats, the reduction in habitat patch size and an increasing isolation of habitat patches (Andrén, 1994; Bender et al., 1998). A change of landscape structure impacts on a variety of ecological processes. It is widely recognised that changes in size and isolation of habitat patches have a negative impact on species richness (Mazerolle and Villard, 1999) and the distribution and persistence of populations (Hanski, 1999). Woodlands are considered as an important habitat for biodiversity conservation in cities. However, they are increasingly under pressure by a diverse range of urban development (OECD, 1997; Kwon et al., 2005). The average loss of woodland for last 10 years has been 5,378ha in the country (Korea Forest Service, 2011). In the case of Gwangju city, 636 ha of woodland between 1995 and 2009 had lost (Gwangju city, 2010). The changes of woodlands will affect the distribution and abundance of animal and plant species and negatively impact on landscape structure and function. However, there is little information on the extent of these changes in the urban fringe areas. This kind of information can be used to set priorities for biodiversity conservation planning and more effective strategies for landscape ecological planning in urban

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regions. Therefore, the aim of this research was to analyze the change, distribution and spatial characteristics of woodlands in an urban fringe landscape.

II. Materials and methods

1. Study area

In previous research (Kim and Pauleit, 2005), fourty-six landscape character units were distinguished for Gwangju city. The landscape character units were distinguished by their unique combination of physical and social landscape factors, such as landform, water features and vegetation areas, built-up areas and agricultural land use patterns. In this study, to characterise the spatial woodland changes between 1976, 1983, 1994, 2002 and 2009 in an urban fringe landscape, one of the urban fringe landscape character units was chosen in the study area (Fig. 1).

The study site had a size of 594 ha and was situated in the northern part of Gwangju. Key characteristics of this landscape are that it dominated by woodlands,

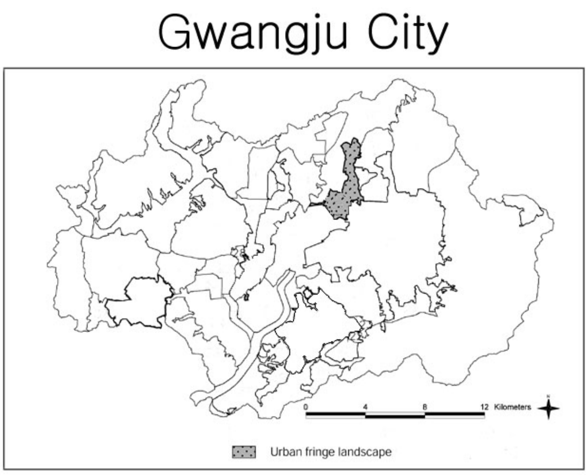

Fig. 1. The selected study area.

high-rise apartment buildings, terraced irregular fields and country villages. Woodlands are surrounded by small to medium-scale, enclosed, terraced, irregular arable and paddy fields. Arable lands are mainly used for rice cultivation on lower slopes of mountains.

2. Data collection and analysis

In this study, 1: 5,000 topographic digital maps and 1: 20,000 black and white aerial photographs (from 1976, 1983, 1994, 2002 and 2009) were used to map woodlands for the case study area. Woodlands were distinguished by visual inspection and then digitized on screen as polygons in Auto CAD. This data was then imported into Geographical Information System software ArcView 3.2 to analyze and display the results. To analyze changes of land cover, this study distinguished nine land cover types and then these land cover types were again aggregated into three general land cover types (Table 1).

To quantify and characterize the spatial pattern of woodland, this study used landscape ecological metrics. The previous study identified suitable landscape metrics to analyse the spatial processes of changes in woodland cover in the study area (Kim and Stephan, 2005 and 2009). This research used Mean Nearest-neighbour Distance (MND) to analyse the degree of isolation of woodland in the study area for 33 years. Nearest neighbor distance was defined in the study as:

$$NND = d_{jk}$$

Where NND equals the nearest-neighbour distance from patch j to another patch k of the same type, based on shortest edge-to-edge distance. The average

Table 1. Land cover classification.

Urban land	Agricultural land	Semi-natural land
Residential land	Arable land	Reservoir
Industrial land	Rice field	River
Built-up area	Orchard	woodland

isolation of patches in summarized simply as the mean nearest neighbor distance over all patches. The previous data of NND from 1976 and 2002 in the study area was used for this research (Kim and Stephan, 2009).

III. Results

1. Change of land cover

Table 2 shows the typical urban fringe landscape type where semi-natural, agricultural and urban land cover types coexist. This landscape consisted of several land cover types which cover approximately the same amount of land: urban land cover (33.8%), agricultural land cover (29.6%) and semi-natural land cover (36.6 %) in 1976. Table 2 shows that this landscape experienced the decrease in woodland cover (−10%) and agricultural land cover (−8.5%) between 1976 and 2009. However, the urban land cover increased from 33.8% in 1976 to 52.3% in 2009.

Overall, the woodland cover gradually declined between 1976 and 2009. Table 3 shows the conversion of woodland lost into different land cover types for 33 years. This landscape had only lost 6.5ha of woodland and this loss of woodland was converted into housing development sites between 1976 and 1983. However, it experienced the strongest decrease in the area of woodland cover (−25.5 ha) between 2002 and 2009. The loss of woodland had been converted into housing (23 ha), followed by road (2.2 ha) and arable and rice field (0.3 ha). At this period, the urban land cover has greatly increased in the urban fringe landscape.

2. Change of woodland

The woodland area gradually decreased from 195.3 ha in 1976 to 135.5 ha in 2009 (Table 4). The woodland area decreased strongest 2009 (−25.5 ha), followed by 2002 (−16.3 ha), 1994 (−11.4 ha) and 1983 (−6.6 ha). The mean size of woodland patches was largest in 1976 (6.1 ha), followed by 2002 (5.7 ha), 1983(5.5 ha), 2009 (5.4 ha) and 1994 (5 ha). The average size of woodland patches decreased strongest between 1976 and 1994 while the average size of woodlands increased between 1994 and 2002 (+0.7 ha). This increase was not a result of woodland expansion but the main reason was that many small patches were lost while fewer large patches remained. Woodland patches in the urban fringe landscape were spatially arranged in large blocks,

Table 2. Change of land cover.

Year	Urban land (%)	Agricultural land (%)	Semi-natural habitats (%)	
			Rivers and reservoirs	Woodland
1976	33.8	29.6	3.8	32.8
1983	36.2	28.3	3.8	31.7
1994	40.3	26.1	3.8	29.8
2002	48.1	21	3.8	27.1
2009	52.3	21.1	3.8	22.8

Table 3. Conversion of woodland lost into different land cover types.

Year	Change of woodland to:				Woodland lost (ha)
	Housing	Other urban	Road	Arable and rice field	
1976-1983	6.5	0	0	0	6.5
1983-1994	8.1	0	3.3	0	11.4
1994-2002	16.5	0	0	0	16.5
2002-2009	23.0	0	2.2	0.3	25.5

Table 4. Change of woodland and MND.

Year	Woodland area (ha)	Mean woodland patch size (ha)	Number of woodland patches	Patch size classes: less 5 ha	5-9.9 ha	Over 10 ha	MNND (m)
1976	195.3	6.1	32	25	2	5	188
1983	188.7 (-6.6)	5.5	34	28	1	5	186
1994	177.3 (-11.4)	5	35	29	1	5	278
2002	161 (-16.3)	5.7	28	23	0	5	287
2009	135.5 (-25.5)	5.4	25	21	0	4	298

Table 5. Number of woodland patches transformed from 1976 to 2009 through common processes.

Year	Dissection	Fragmentation	Shrinkage	Attrition	Expansion
1976-1983	0	2	2	0	0
1983-1994	0	1	4	0	0
1994-2002	0	0	4	7	0
2002-2009	0	1	8	3	0

with patch sizes of more than 10 ha (n=5) between 1976 and 2002. There was a significant decrease in number of woodland patches of less than 5 ha in size during 1994 and 2009. While there was a slight increase in number of woodland patches (less than 5 ha in size) between 1976 and 1994 because urban developments in woodlands caused the fragmentation of woodland patches (Table 5). MND was found to be greatest in 2009, suggesting that woodland patches were the most isolated in this period, while the MND was smallest in 1983, followed by in 1976, suggesting that patches were more closely neighboured (Table 4). MND suggested that the woodland patches in the study area became the most isolated during 1976 and 2009, because shrinkages and attritions of woodland patches due to a range of urban fringe developments.

Table 5 indicates that woodland patches were dynamic in the study area. Woodlands suffered from shrinkage, attrition and fragmentation during 1976 and 2009. Mainly residential and road developments have led to strong shrinkage and attritioin of woodlands between 1994 and 2009 (Fig. 2). Especially, ten woodlands were moved by attrition and converted into road and residential uses during 1994 and 2009.

Fig. 2. Change of woodland spatial processes.

IV. Discussion and Conclusions

The research indicates that the urban fringe land-scape dominated by a cover of urban, agricultural and natural land cover types, has a distinctive and somewhat vulnerable landscape character, and contains high ecological values and somewhat stable ecological conditions. This landscape has been altered much more fundamentally and in shorter time periods than ever before by activities including agriculture, built development, transport, and recreation. This process results in rapid change in landscape ecological conditions.

There was a common trend of woodland loss across all landscape types while no new woodlands were established during 1976 and 2009. Small patches (less than 5ha in size) were particularly vulnerable to and more likely to disappear due to human activities such as urbanisation. Changes in woodland cover were clearly observed between 1976 and 2009. Loss of many woodlands was caused by residential and infrastructural developments. As a result, woodlands were becoming smaller and more isolated. This trend probably had adverse effects on biodiversity. Especially, woodlands have been highly dynamic for the last 33 years in the study area. In 1976, this landscape had large and less isolated woodlands. The urban fringe landscape still has relatively large woodland patches (more than 10 ha in size), but these woodlands have become more isolated in the study area because small woodlands have been lost.

The larger woodlands can provide good opportunities to enhance dispersal of wildlife. A woodland area of 10 ha or more is suggested as a proper size to support a high probability of breeding of many area-sensitive and interior woodland avian species (Hinsley et al. 1994; McIntyre 1995). This situation could further deteriorate if sufficient safeguards are not put in place to protect woodlands from the small size and scattered idyllic housing developments. Similar to urban landscapes, it is difficult to create new woodlands in the urban fringe landscape because of high land prices. Therefore, existing large woodlands should be strictly protected as core habitats and targeted for the creation of an ecological network. New green corridors can be established to connect the fragmented remains of the woodland infrastructure. Such a network of woodland patches and green corridors would provide a higher connectivity of woodlands and would constitute a necessary tool for the preservation of interconnections between urban and rural agricultural woodlands in the urban fringe landscape. This would give greater opportunities for local species population to increase and to disperse into neighbor woodlands in urban and agricultural landscapes.

For the successful implementation of biodiversity issues into planning, the interrelations between woodland change and biodiversity must be considered. This woodland information can be used to identify the potential and specific needs for conservation planning in rapidly developing urban areas. This research only used Mean Nearest-neighbour Distance (MND) for landscape ecological analysis. For more information of landscape ecological conditions, a more comprehensive analysis based on landscape ecological metrics is needed. Up-to-date satellite images with a high resolution will be also needed for improved data collection and analyses of woodland change in the future.

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