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Biotop Mapping Using High-Resolution Satellite Remote Sensing Data, GIS and GPS

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Abstract : Biotop map can be utilized for nature conservation and assessment of environmental impact for human activities in urban area. High resolution satellite images such as IKONOS and KOMPSAT1-EOC were interpreted to classify land use, hydrology, impermeable pavement ratio and vegetation for biotop mapping. Wildlife habitat map and detailed vegetation map obtained from former study results were used as ground truth data. Vegetation was investigated directly for the area where the detailed vegetation map is not available. All these maps were combined and the boundaries were delineated to produce the biotop map. Within the boundary, the characteristics of each polygon were identified, and named. This study investigates the possibility of biotop mapping using high resolution satellite remote sensing data together with field data with the goal of contributing to nature conservation in urban area.

Key Words : Biotop Map, Nature Conservation, Land Use, Wildlife, Vegetation, Visual Interpretation.

1. Introduction

Urban areas have expanded rapidly in South Korea since 1960's. Due to urbanization many urban forests disappeared. As results, wildlife habitat is fragmented and shrunk. This urban situation requires new ways to approach the biodiversity issue. To maintain a characteristic flora and fauna as well as the functionality of ecosystem, we must consider how land use changes will influence the biotop in urban area (Katarina. L., *et al.*, 2002). Efforts to restore these deteriorated habitats have been made recently. Green network connection and biotop mapping are some of these efforts. A large city is made up of a number of habitats, each with specific biotic communities. They have survived by adapting to the conditions of the urban environment. The prerequisite for successful nature conservation strategies is knowledge of the individual biotop, their ecological characteristics, location and distribution in the city and the composition of their plant and animal communities (Sukopp and Weiler, 1988).

Biotop mapping requires the detailed and accurate environmental information such as vegetation, land use, etc. One of the methods to acquire site information is to use high resolution satellite remote sensing data. High resolution remote sensing data such as IKONOS images are being acquired at higher spatial and temporal resolution. Therefore, various land information data can be acquired precisely by visual interpretation. Moreover, these data can save time and efforts for field-work.

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The availability of Remote Sensing (RS) data for global, regional and local environmental monitoring has greatly increased over recent years. New technologies such as Global Positioning System (GPS), digital photogrammetry and multi-source satellite remote sensing are opening new application fields for remote sensing (Ehlers *et al.*, 2003). Recent studies about biotop mapping using high resolution satellite images and airborne data are implemented (Cousins and Ihse, 1998; Ehlers *et al.*, 2003; Thomson *et al.*, 1999). Cousins and Ihse (1998) suggested a new classification system based on a relatively quick and accurate biotop mapping using RS data. According to their conclusions, the mapping rate was 1.4-2.8㎢/hour and interpretation accuracy was 95-99%. Ehlers *et al.* (2003) presented development of an automated procedure for biotop mapping from remote sensing data. High resolution satellite images and digital airborne offer new possibilities for accurate mapping.

In Korea, several studies about biotop mapping in urban area have been carried out for urban ecosystem restoration and nature conservation. Some studies were carried out to construct an evaluation criteria based on the relative importance and various combinations of each evaluation index (Ra and Park, 1998; Ra *et al.*, 2001; Ra and Ryu, 2002; Ra and Do, 2003). Oh and Lee (2000) carried out their study for urban nature conservation by assessing the biotop in the new town. However, such biotop studies require time consuming efforts for fieldwork. So, it is necessary to save time and efforts for fieldwork. RS and Geographic Information System (GIS) can provide the methodology to save time and efforts for biotop mapping.

Therefore, this study aims to investigate the possibility of biotop mapping using high resolution satellite remote sensing data together with field data and eventually, to contribute to the nature conservation in urban area.

2. Materials and Method

1) Study Site

The study site was Daedok Science Town in Taejeon

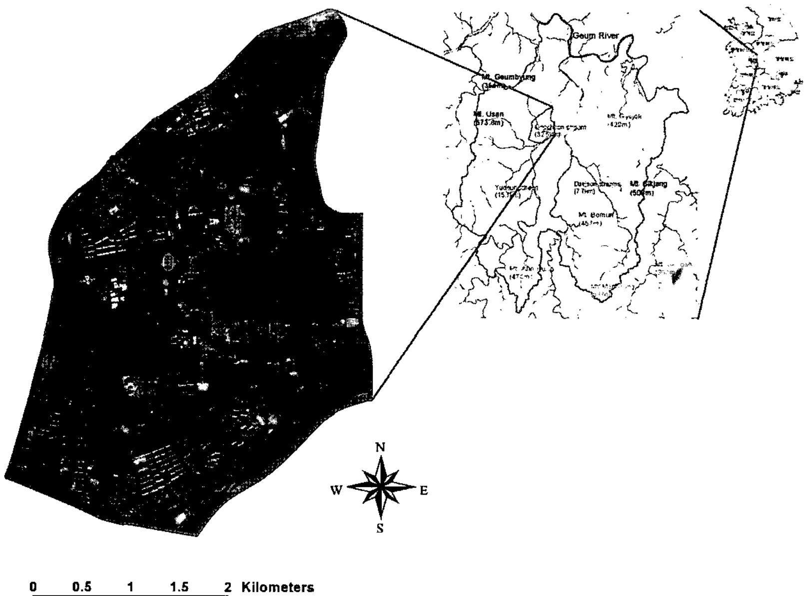

Fig. 1. Study site.

metropolitan area located at the central part in South Korea. From 1970's the population of the science town has grown rapidly mainly due to the relocation of government institutes (Ahn and Lee, 2003). There are institute facilities and education facilities in the study site. Also, Kahp Stream is located at southern part of the study site. Kahp Stream is the major stream in Daejeon City. Urban forest areas are preserved well in the study site. Also, the stream water is flowing continuously at Tahndong Stream, even in dry winter season. Because the surrounding forest at upper stream serves as aquifer. Also the land use is regulated as military security zone (Lee *et al.*, 2003). In addition, some mammals and birds are confirmed at Tahndong stream and its surrounding forest area in the study site (Kang and Lee, 2001). A flora and fauna was checked in the fieldwork (Her *et al.*, 2001; Kang and Lee, 2001). Fig. 1 shows the location and geography of the study site.

2) Data

For RS data, Korea Multi-Purpose Satellite 1 (KOMPSAT1) Electro Optical Camera (EOC) images and IKONOS satellite images were used (Table 1). For thematic data, 1:5,000 scale digital topographic maps were used to select ground control points (GCP's). Digital map of ecological wildness and digital vegetation map were used for producing biotop map. Wildlife habitat and detailed vegetation map referred to the previous study results (Ahn and Lee, 2003; Her *et al.*, 2001). Vegetation was investigated for the area where the detailed vegetation map is not available. Tables 1 and 2 show RS/GIS and other thematic data used in this study, respectively.

Table 1. RS data used in this study.

Data source	Resolution	Date	Data type
KOMPSAT1 EOC	6.0m	2000. 3. 1 2000. 3. 9 2000. 5. 8 2000. 10. 2 2000. 10. 27	Digital Panchromatic
IKONOS	1.0m	2000. 7. 27 2001. 11. 19	Digital Pan-Sharpened

3) Method

KOMPSAT1 EOC images were geometrically corrected by the second order polynomial transformation and resampled into 6.0m resolution image by cubic convolution. And IKONOS images were geometrically corrected by the first order polynomial transformation and resampled into 1.0m resolution image by nearest neighborhood as we can see in Table 1.

First, IKONOS and KOMPSAT1 EOC images were visually interpreted for biotop mapping. Then field survey was done to conduct vegetation correction. Land use was classified using IKONOS and KOMPSAT1 EOC images. Then vegetation map was produced using visual interpretation results, detailed vegetation map (DVM) and field survey. Former study results were used in making wildlife habitat map. Hydrologic map was produced based on the stream order from 1:5,000 scale topographic maps and IKONOS image interpretation. Finally, impermeable pavement ratio map was produced from IKONOS image interpretation and field check. These maps were combined and the boundaries were

Table 2. Other thematic data used in this study.

Data source	Scale	Date	Data type	Publisher
Topographic Map	1:5,000	1996	Digital	Korea National Geography Institute
Detailed Vegetation Map	1:5,000	2000 2003	Digital	Landscape Information Lab., Dept. of Landscape Architecture, SKKU.
Map of Ecological wildness	1:25,000	2002	Digital	Korean Ministry of Environment

delineated to produce the biotop map. Within the boundary, the characteristics of each polygon were identified, and named. For visual interpretation of RS data, IKONOS data were mainly used. KOMPSAT1 EOC satellite images were interpreted for the areas where IKONOS images cannot provide the actual data for the security reason.

Location of data collected in fieldwork was recorded by Global Positioning System (GPS) receivers, coordinates are converted to Transverse Mercator (TM) coordinates, and database was produced using GIS. Garmin eTrex venture GPS receiver was used for fieldwork in vegetation mapping. For RS and GIS software, PCI (RS) and ArcView (GIS) were used in this study.

3. Results and Discussion

An IKONOS image was used to detect boundary of vegetation community, impermeable pavement ratio, stream order and land use in urban areas by visual interpretation. Especially visual interpretation of impermeable pavement ratio could be done easily in the study area. Consequently, using high resolution satellite image could save time and efforts for fieldwork in biotop mapping.

Patch distribution map was produced based on the land use classification. It shows the degree of human intervention in the landscape. Vegetation map was produced by IKONOS interpretation, detailed vegetation map (DVM) and fieldwork. Wildlife habitat map obtained from former studies was used. There are three classes: raccoon habitat forests (28.7%), other forests (6.3%) and other land use (65.0%) type because raccoon is the indicator species in the study area. They are based on the field check (Ahn and Lee, 2003). Hydrologic map was produced based on the stream order interpretation from topographic maps and IKONOS image interpretation. There are three classes: third stream order (3.2%), fifth stream order (40.9%) and sixth stream order (55.9%). Impermeable pavement ratio map was produced from IKONOS interpretation and field check. There are six classes: less than 10% (46.9%), 10-30% (0.8%), 30-50% (35.8%), 50-70% (4.3%), 70-90% (3.7%), over 90% (8.5%) (Seoul Development Institute, 2000). Table 3 shows each thematic map utilized in this study.

Biotop type was produced by overlaying each thematic map, which is shown in Table 4. In terms of biotop type evaluation, the first priority was given to wildlife habitat conservation. Next it was given to impermeable pavement ratio, then open space sequentially. In the first level classes, more priority is given to streams where footprint of raccoon and birds were found, which means wildlife corridor at Tahndong Stream and its surrounding area. Class 1 to 2 are green space area which are forest and river. Class 3 is crop area, grass field, pond, tomb and landscaping area. These areas should be preserved because it has natural potential. Class 4 is semi open space area such as playground, etc. In this area, the development is restricted because wildlife moves at night. The other classes are non-open space areas. These areas need to be improved in terms of natural potential. In terms of land

Table 3. Thematic maps utilized in this study.

thematic map	method of mapping
patch distribution map	RS image interpretation
vegetation map	RS image interpretation and fieldwork
hydrologic map	RS image interpretation and topographic map
impermeable pavement ratio map	RS image interpretation and fieldwork

Table 4. Biotop type evaluation.

Wildlife	Land use type	Impermeable pavement ratio	Stream order	Area (ha)	Percentage (%)	Biotop Evaluation		
						class	area(ha)	%
raccoon habitat forest	forest	less than 10%	-	350.8	27.3	1	369.5	28.7
	river system	less than 10%	3rd	1.6	0.1			
		less than 10%	5th	17.0	1.3			
other forest	forest	less than 10%	-	80.7	6.3	2	113.3	8.8
other land use	river system	less than 10%	5th	4.0	0.3			
		less than 10%	6th	28.7	2.2			
	agricultural area	less than 10%	-	73.8	5.7	3	119.0	9.3
	grass field	less than 10%	-	41.9	3.3			
	pond	less than 10%	-	2.3	0.2			
	tomb	less than 10%	-	0.7	0.1			
	landscaping area	less than 10%	-	0.2	0.0			
	bare soil	less than 10%	-	1.5	0.1	4	472.2	36.7
	sport facilities	10-30%	-	10.6	0.8			
	education facilities	30-50%	-	209.4	16.3			
	institute facilities	30-50%	-	249.7	19.4			
	military base	30-50%	-	1.0	0.1			
	single residence	50-70%	-	10.8	0.8	5	55.2	4.3
	low rise res.	50-70%	-	10.4	0.8			
	medium rise res.	50-70%	-	4.7	0.4			
	high rise res.	50-70%	-	29.3	2.3			
	mixed res. & com.	70-90%	-	41.9	3.3	6	48.0	3.7
	commercial facilities	70-90%	-	3.1	0.2			
	public office	70-90%	-	1.1	0.1			
	transformer substation	70-90%	-	1.9	0.2			
	parking area	over 90%	-	28.1	2.2	7	108.7	8.5
	road	over 90%	-	80.6	6.3			
total				1286.0*	100.0*	-	1286.0*	100.0*

* rounding error

use control, biotop type area that has high degree of nature potential needs to be preserved and the land use which might disturb the current environment would be strictly restricted.

After evaluating biotop in the study area in this scheme, the area is classified into seven classes. Fig. 2 shows results of biotop type evaluation. Class 1 is the highest degree of natural potential. So, it needs to be preserved. It includes raccoon habitat forest and Tahndong Stream area (369.46ha, 28.7%). Class 2 has high value of natural potential. So, it also needs to be preserved. It includes other forests and Kahp Stream area (113.33ha, 8.8%). Class 3 includes agricultural area, grass field, pond, tomb and landscaping area (118.95ha, 9.3%). Class 4 needs to limit development because it provides wildlife corridor at night. It includes sport facilities, bare soil, education facilities, institute facilities and military base (472.23ha, 36.7%). Class 5 includes residential area (55.19ha, 4.3%). Class 6 includes mixed residential and commercial facilities, commercial facilities, public office and transformer substation (47.98ha, 3.7%). Class 7 is the lowest degree of natural potential. It includes parking area and road (108.68ha, 8.5%).

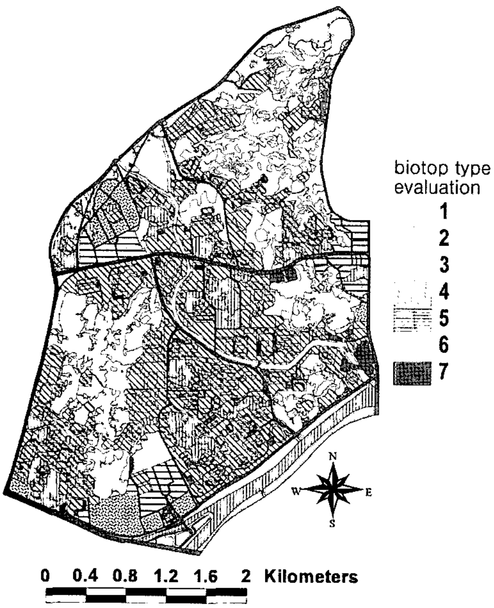

Fig. 2. Biotop type evaluation map.

Several forests are preserved comparatively well even if the study area is urban area. The dominant species are *Pinus densiflora, Pinus thunbergii, Castanea crenata, Pinus rigida, Quercus acutissima* and *Robinia pseudo-acacia*. This means that, they are not natural forest. However, the dominant understory species are *Quercus serrata* and *Quercus aliena*, which means natural succession is proceeding. They will be dominant tree layers in the future if there is no external disturbance. In addition, the water quality at Tahndong Stream is good and a fair amount of water is flowing even in dry winter season because there are good aquifers at the upper stream zone. The raccoon habitat occupies 28.7% of the study area. 46.8% of the study area is the first to third biotop type. It is relatively well preserved urban area.

After making biotop type evaluation map, the result is confirmed with field check. This map can be used as evaluation criteria for wildlife habitat conservation and land use control. Also it can be used as a basis for future restoration plan because it shows the current status of wildlife and vegetation.

4. Conclusions

This study was carried out to investigate the possibility of biotop mapping using high resolution satellite remote sensing data together with field data and eventually, to contribute to the nature conservation in urban area. There are some conclusions derived from this study.

High resolution satellite images like IKONOS images can be used for biotop mapping in urban area by delineating land cover and vegetation communities. It can save time and efforts for fieldwork.

Biotop type can be classified into several classes according to the degree of naturalness in urban area. In this case, there are seven classes in terms of biotop type. 46.8% of the study area is the first to third biotop type. It is relatively well preserved urban area.

Biotop type can be used as evaluation criteria for wildlife habitat conservation and land use control. Also it can be used as a basis for future restoration plan because it shows the current status of wildlife and vegetation.

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