An Analysis of Vegetation Status in an Urban Natural Park
- Focus on Seoo Royal Tomb -

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ABSTRACT

Recently there have been increasing demands and desire for urban open space due to urban development or environmental deterioration. Urban natural parks in Seoul provide citizens with comfortable open space and thus play an important role as learning spaces to experience nature and understand the environment. Accordingly, this study aims to analyze existing vegetation and provide basic data for the conservation and management plans of urban natural parks and education programs.

The contents of the study encompass natural environment such as topography, altitude, slope and aspect and botanical ecosystem including the structure of plant communities and tree growth.

According to the result of topography analysis, the overall altitude was not high but the slope was relative steep. Vegetation of Seoo Royal Tomb, a urban natural park has been classified into 12 types, and they include: Quercus acutissima community(lowland type), Quercus acutissima community(valley type), Quercus variabilis community, Quercus mongolica community, Castanea crenata community, Capinus laxiflora community, Pinus densiflora community(lowland type), Pinus densiflora community(slope type), Robinia pseudo-acacia community, Populus × albaglandulosa community, Pinus rigida community, and Pinus koraiensis community. Based on the survey and analysis results, we have classified the study area into conservation, buffer, and utilization zones for the effective management. This study provides basic data to support the establishment of master plans for urban natural parks by analyzing vegetation conditions at Seoo Royal Tomb, an urban natural park. Based on the results presented in the study, consistent monitoring work needs to be conducted, and elaborate management plans also should be prepared.

Key Word : Seoo Royal Tomb, Urban natural park, Vegetation satatus, Vegetation type

I. INTRODUCTION

Recently there have been increasing demands and desire for urban open space due to urban development or environmental deterioration. People are paying renewed attention to the importance of ecological restoration and management of damaged urban forests based on existing vegetation. That is,

urban forests have been under environmental and human influences which have resulted in forest fragmentation and the loss of ecological buffer zones, leading to the quantitative and qualitative deterioration of forest ecosystems. Consequently, there has been active involvement in protecting indigenous biotic communities and natural ecosystems. In addition, more emphasis is placed on understanding ecological information on the target forests by type and classifying them in order to establish appropriate management plans for the forest ecosystem(Cho, 1998).

Urban natural parks in Seoul provide citizens with comfortable open space and thus play an important role as learning spaces to experience nature and understand the environment. In terms of damage to the natural ecosystem, however, we see many problems in the urban natural parks including: indiscreet vegetation management; sporadic occurrence of paths up mountains; and annual shrub cutting work for massively planted trees for landscaping. Accordingly, this study aims to analyze existing vegetation and provide basic data for the conservation and management plans of urban natural parks and education programs. Geographically, this study focuses on Seoo Royal Tomb, which is negligently managed without supporting facilities therefore doesnt meet users demands, as well, the natural environment is continuouly being damaged because of excessive use.

II. STUDY CONTENTS AND METHODS

The study area, Seoo Royal Tomb, is an urban natural park, which is situated in Gupabal-dong, Eunpyeong-gu, Seoul and bordering Goyang City, Gyeonggi Province. In terms of urban ecology, the study area stretches south to north and is a part of the suburban ring forest in the west of Seoul, where Mt. Bukhan and the Han River meet. Recently, indiscreet use has caused such damage to the vegetation that a management plan needs to be established based on the current vegetation conditions. The survey and analysis were conducted from July through August 2001.

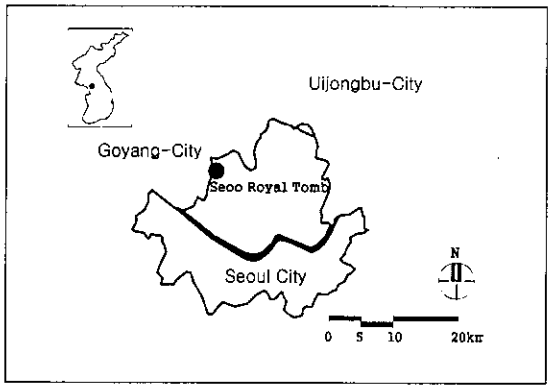


Figure 1. Location of Seoo Royal Tomb urban natural park

The contents of the study encompass natural environment such as topography, altitude, slope and aspect and botanical ecosystem including the structure of plant communities and tree growth.

For topographical analysis, we utilized digitized maps provided by the National Geography Institute. We sorted out contour lines and altitude points from a 1/5,000 scale map and conducted a three-dimensional analysis using Arc/Info Grid modules. For vegetation, we performed a complementary survey based on the biotope map that was prepared by Seoul City in the year 2000. According to the survey results, we classified the types of vegetation and then conducted analysis of the structure of plant communities and measured tree growth.

The analysis information on the structure of vegetation communities consists of overall conditions of each site, vegetation survey results,

relative dominance, and species diversity. The size of a survey plot was set as a unit area of 10m× 10m(100㎡) using the quadrat method. The survey results at each plot include: altitude; aspect; mean height, mean DBH and coverage of canopy layers; mean height, mean DBH and coverage of understory layers; mean height and coverage of shrub layers; and mean height and coverage of herbaceous layers; and age of forest. The survey of vegetation was done with its target on tree species within the boundary of the plots. The location of canopy and understory layers was marked on a map according to their heights, and layers with DBHs lower than 2 cm were classified into shrub layers(Park, 1985). In particular, the dominance and sociability of herbaceous plants were analyzed using the Braun-Blanquet(1964) method. For the analysis of relative dominance, we applied the Curtis and McIntosh(1951) method to figure out importance values(I.V.), and mean importance values(M.I.V.) were calculated considering tree heights. As for the analysis of species diversity, we used the Shannon index(Pielou, 1975) to calculate diversity index, H'max, evenness, and dominance. To analyze growth conditions of trees, we selected representative trees of each vegetation type and extracted a growth ring at a height of 1.2 m.

III. STUDY RESULTS

1. Topography Analysis

According to the result of topography analysis, over 80% of the altitude showed values lower than 150meter, with only 2% of that being a height of 200meter, and the overall topography was lowland. Ninety percent of the whole area showed a slope of over 20%. The overall altitude was not high but the slope was relative steep. As for aspects, more than 60% of them were facing northeast, east, and southeast.

2. Analysis of the structure of plant communities

1) Overall conditions of the study area

Most urban open spaces of the country are composed of forests. Since 1960, afforestation projects have been done centering on *Robinia pseudo-acacia*, *Pinus rigida* and *Populus*×*albaglandulosa*. Current forest vegetation is dominated by *Robinia pseudo-acacia*, *Populus*× *albaglandulosa*, and *Pinus rigida*. However, with the predominance of native *Quercus* spp., such as *Quercus mongolica*, they are competing with afforested species(Lee, K. *et al.*, 1994). A complementary survey of present vegetation has been done based on the biotope map prepared by Seoul City in the year 2000.

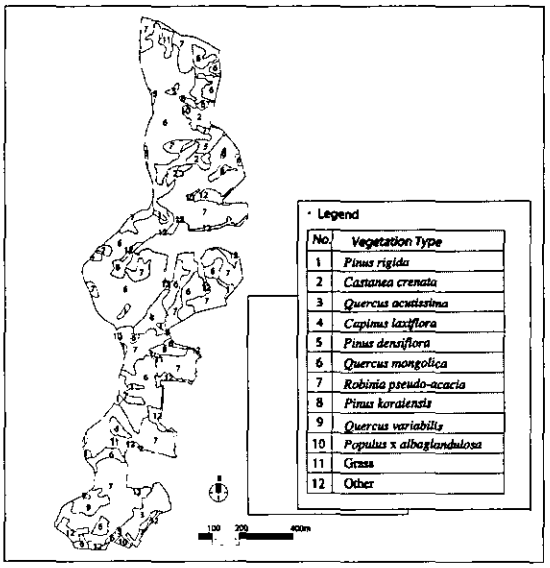


Figure 2. Actual vegetation map of Seoo Royal Tomb urban natural park
Resource: Seoul City(2000) Seoul Biotope Map.

According to the results, the *Robinia pseudo-acacia* community was distributed over broad areas accounting for 511,768.3㎡(42.8%) of the total area,

Table 1. Area and Ratio of vegetation types in Seoo Royal Tomb urban natural park

Vegetation types (community)	Area(㎡)	Ratio(%)
Pinus rigida	17,018.9	1.4
Castanea crenata	18,474.7	1.5
Quercus acutissima	31,272.6	2.6
Capinus laxiflora	2,350.1	0.2
Pinus densiflora	17,357.7	1.5
Quercus mongolica	384,700.9	37.7
Robinia pseudo-acacia	511,768.3	42.8
Pinus koraiensis	40,312.6	3.4
Quercus variabilis	17,096.2	1.4
Populus×*albaglandulosa*	4,874.5	0.4
Grass	10,311.0	0.9
Other	74,034.1	6.2
Total	1,129,571.6	100.0

and the *Quercus mongolica* community held a proportion of 384,700.9㎡(37.7%). It was found that native *Quercus* spp. was spreading out its territory to some understory layers of the *Robinia pseudo-acacia* community. Other main communities include: *Quercus acutissima* community, *Quercus variabilis* community, *Castanea crenata* community, *Capinus laxiflora* community, Pinus *densiflora* community, *Populus*×*albaglandulosa* community, *Pinus rigida* community, and *Pinus koraiensis* community(Figure 2). The *Quercus acutissima* community was classified into lowland types and valley types, and the *Pinus densiflora* community was also classified into lowland types and slope types. Overall the communities consisted of 12 types. Among vegetation types, the *Capinus laxiflora* community, which is a climax community in Seoul City and needs immediate protection measures, accounted for a small proportion of 2,350

Table 2. General character list of vegetation types in Seoo Royal Tomb urban natural park

General character list	Vegetation types											
	Quercus acutissima		*Quercus variabilis*	*Quercus mongolica*	*Castanea crenata*	*Capinus laxiflora*	*Pinus densiflora*		*Robinia pseudo-acacia*	*Populus ×albaglandulosa*	*Pinus rigida*	*Pinus koraiensis*
Altitude (m)	60	70	150	120	65	135	105	45	105	85	175	175
Aspect	NE	SE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Slope (°)	10	20	27	30	15	23	30	7	20	15	30	15
configuration	lowland	valley	slope	slope	slope	slope	slope	lowland	slope	slope	slope	slope
Height of canopy(m)	12	15	15	12	12	10	7	15	12	12	12	7
Mean DBH of canopy(cm)	30	20	20	25	20	15	15	40	30	20	20	10
Cover of canopy(%)	50	23	50	60	50	60	40	30	50	50	25	80
Height of understory(m)	5	5	3	6	7	2	2.5	4	5	7	6	-
Mean DBH of understory(cm)	7	5	5	4	5	3	4	8	4	5	5	-
Cover of understory(%)	5	30	20	20	20	10	15	20	20	20	40	-
Height of shrub(m)	1.5	1.5	0.6	0.8	1.2	0.8	1.2	0.6	0.8	1.5	1.5	0.5
Cover of shrub(%)	40	15	10	20	15	10	40	20	20	15	30	5
Mean height of herbaceous(m)	0.3	0.2	0.2	0.5	0.4	0.4	0.3	0.3	0.5	0.5	0.3	0.4
Coverage of herbaceous(%)	20	60	20	15	20	5	20	5	20	20	5	5
Age of forest	24	26	23	27	23	17	19	40	31	29	27	19

㎡(0.2%).

Table 2 presents the overall status of each vegetation type. The *Quercus acutissima* community was classified into lowland types and valley types, and the distribution of trees wide in diameter was large in the lowlands. In the *Quercus variabilis* community, a variety of Quercus spp. species such as *Quercus acutissima*, *Quercus dentata* were observed. The *Quercus mongolica* community was distributed on a large scale but most of them were young trees growing on the slopes that are inaccessible. Thus, the survey was done in plots where trees wide in diameter were remnant. Areas planted with *Castanea crenata* were located around the adjacent residential area and appeared to be heavily influenced by human disturbances. In addition, *Capinus laxiflora*, which is a rare climax species in Seoul, was observed but has been damaged in understory and shrub layers as well as canopy layers by severe shrub cutting work. Its mean DBH was 15 cm, indicating that the community is in the young stage. The *Pinus densiflora* community was scattered on the slopes on a small scale but in the lowlands around the residential area the mean DBH of its canopy layers reached 40 cm forming good landscape.

The *Robinia pseudo-acacia* community occupies the largest area in Seoo Royal Tomb which is an urban natural park, and its mean DBHs ranged from 25 to 35 cm, which are criteria for trees wide in diameter. In some understory layers of the *Robinia pseudo-acacia* community, *Quercus mongolica* was a dominant species, and the community is expected to be succeeded by *Quercus* spp.

2) Importance value

Tables 3 and 4 show the importance value of each vegetation type and the dominance and sociability of herbaceous layers. *Quercus acutissima* was predominant in the *Quercus acutissima* community growing in the lowlands and valleys. In the lowlands, Sorbus alnifolia(I.V.: 74.0%) and *Robinia pseudo-acacia*(I.V.: 26.0%) were the main species. This observation indicates that *Sorbus alnifolia* is a tolerant species in the urban environment and spreading out over the city as a main species. Herbaceous layers differed in the species composition between lowlands and valleys. While species such as *Oplismenus undulatifolius*, *Commelina communis*, and *Persicaria hydropiper* appeared in the lowlands, *Disporum smilacinum* formed a community with a coverage of over 30% in the valleys. Also *Convallaria keiskei* and *Viola verecunda* were distributed. This survey result is congruent with that of the study which concluded that species such as *Ainsliaea acerifolia*, *Disporum smilacinum*, *Polygonatum humile*, and *Convallaria keiskei* appear where high levels of naturalness are maintained(Ko, 1991). In this regard, elaborate conservation measures are required to protect against damage of herbaceous layers in Seoo Royal Tomb.

In the importance value analysis of the *Quercus variabilis* community, *Quercus variabilis*(I.V.: 46.59%) was predominant in the canopy layers, and *Quercus acutissima*(I.V.: 35.29%) and *Quercus dentata*(I.V.: 18.13%) also appeared as main species. As for the understory layers, *Quercus dentata*(I.V.: 23.66%), *Rhododendron mucronulatum*(I.V.: 20.53%), Pinus densiflora(I.V.: 15.74%), and *Quercus mongolica*(I.V.: 14.7%) were mainly observed, and *Sorbus alnifolia* and *Prunus sargentii* also appeared as secondary species. In the shurb layers, *Pueraria thunbergiana*(I.V.: 32.27%) was predominant, and *Rubus crataegifolius*, *Quercus serrata*, and *Corylus sieboldiana* were main species. The structure of the

community was stable, because *Quercus* spp. composed the main layer.

In terms of vegetation structure, we have found various species composition in the layers of canopy, understory, and shrub, in which *Quercus variabilis*, *Quercus acutissima*, *Quercus dentata*, and *Quercus mongolica* were main species. In the herbaceous layers, however, *Oplismenus undulatifolius* and *Spodiopogon sibiricus* formed a main species group, resulting in a low coverage.

As for the analysis of the *Quercus mongolica* community, *Quercus mongolica* was predominant in the layers of canopy and understory, and *Rhododendron mucronulatum*(I.V.: 60.13%), *Parthenocissus tricuspidata*, and *Quercus mongolica* appeared mainly in the shrub layers. The species composition of the herbaceous layers was similar to that of the *Quercus variabilis* community, and *Pteridium aquilinum* var. *latiusculum* was predominant.

The *Castanea crenata* community has developed in lowlands and has severely been damaged by human disturbances. *Castanea crenata*(I.V.: 85.33%) was predominant in the canopy layers, and *Sorbus alnifolia*(I.V.: 64.76%) and *Prunus sargentii*(I.V.: 20.72%) were dominant species in the understory layers. As for the shrub layers, *Rhododendron mucronulatum*(I.V.: 66.57%) was a dominant species, and *Prunus sargentii*, *Quercus mongolica*, and *Fraxinus rhynchophylla* were secondary species.

Capinus laxiflora(I.V.: 85.5%) and *Quercus*

Table 3. Importance value of tree species by the layer in Seoo Royal Tomb urban natural park

Layer / Species name	*Quercus acutissima (lowland)*				*Quercus acutissima (valley)*				*Quercus variabilis*				*Quercus mongolica*				*Castanea crenata*				*Capinus laxiflora*			
	C[a]	U[b]	S[c]	M[d]	C	U	S	M	C	U	S	M	C	U	S	M	C	U	S	M	C	U	S	M
Pinus densiflora	-	-	-	-	-	-	-	-	-	15.74	-	5.25	-	-	-	-	-	-	-	-	-	-	-	-
Juniperus rigida	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.76	0.96
Populus×albaglandulosa	-	-	2.91	0.49	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Capinus laxiflora	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	85.5	48.18	-	58.81
Corylus heterophylla	-	-	7.44	1.24	-	-	-	-	-	-	-	-	-	-	5.96	0.99	-	-	-	-	-	-	-	-
Corylus sieboldiana	-	-	-	-	-	-	-	-	-	4.76	12.9	3.74	-	-	-	-	-	-	-	-	-	-	-	-
Castanea crenata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	85.33	-	-	42.67	-	-	-	-
Quercus acutissima	100	-	-	50.0	94.02	16.61	-	52.55	35.29	-	-	17.65	-	10.07	-	3.36	8.04	-	-	4.02	-	-	-	-
Quercus variabilis	-	-	-	-	-	-	-	-	46.59	-	-	23.30	-	-	-	-	-	-	-	-	-	-	-	-
Quercus aliena	-	-	14.19	2.37	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Quercus dentata	-	-	-	-	5.98	-	-	2.99	18.13	23.66	8.07	18.30	-	-	-	-	-	-	-	-	-	-	-	-
Quercus mongolica	-	-	-	-	-	-	-	-	-	14.70	-	4.90	77.26	47.94	12.87	56.76	-	14.52	5.61	5.78	14.50	-	23.02	11.09
Quercus serrata	-	-	-	-	-	-	-	-	-	-	14.26	2.38	22.74	-	-	11.37	-	-	-	-	-	-	-	-
Sorbus alnifolia	-	74.0	-	24.67	-	-	-	-	-	5.52	-	1.84	-	-	-	-	-	64.76	-	21.59	-	17.55	-	5.85
Rubus crataegifolius	-	-	15.59	2.60	-	-	9.92	1.65	-	-	14.26	2.38	-	-	-	-	-	-	-	-	-	-	-	-
Prunus sargentii	-	-	3.74	0.62	-	-	1.98	0.33	-	7.70	8.37	3.96	-	12.73	-	4.24	-	20.72	13.20	9.11	-	11.33	-	3.78
Lespedeza cyrtobotrya	-	-	7.44	1.24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pueraria thunbergiana	-	-	-	-	-	-	-	-	-	-	32.27	5.38	-	-	7.69	1.28	-	-	-	-	-	-	-	-
Robinia pseudo-acacia	-	26.0	46.2	16.35	-	-	-	-	-	7.39	-	2.46	-	-	-	-	6.64	-	-	3.32	-	-	-	-
Rhus trichocarpa	-	-	-	-	-	-	2.03	0.34	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9.68	1.61
Parthenocissus tricuspidata	-	-	2.61	0.44	-	-	-	-	-	-	-	-	-	-	13.35	2.23	-	-	-	-	-	-	-	-
Rhododendron mucronulatum	-	-	-	-	-	-	20.46	3.41	-	20.53	9.88	8.49	-	-	60.13	10.02	-	-	66.57	11.10	-	22.95	61.55	17.91
Symplocos chinensis for. pilosa	-	-	-	-	-	3.84	-	1.28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fraxinus rhynchophylla	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9.94	1.66	-	-	-	-
Smilax sieboldii	-	-	-	-	-	-	9.89	1.65	-	-	-	-	-	-	-	-	-	-	4.69	0.78	-	-	-	-

(Table 3. Continued)

Layer / Species name	*Pinus densiflora (lowland)*				*Pinus densiflora (slope)*				*Robinia pseudo-acacia*				*Populus×albagla ndulosa*				*Pinus rigida*				*Pinus koraiensis*			
	C	U	S	M	C	U	S	M	C	U	S	M	C	U	S	M	C	U	S	M	C	U	S	M
Pinus koraiensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100	-	-	50,0
Pinus rigida	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	78,65	-	-	39,33	-	-	-	-
Pinus densiflora	100	-	-	50,0	100	92,59	-	80,86	-	-	-	-	-	12,86	-	4,29	7,62	-	-	3,81	-	-	-	-
Populus×lbaglandulosa	-	-	-	-	-	-	3,94	0,66	-	-	-	-	85,78	10,84	29,89	51,49	-	-	-	-	-	-	-	-
Vitis coignetiae	-	-	1,43	0,24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Corylus sieboldiana	-	-	-	-	-	-	-	-	-	-	63,75	10,63	-	-	-	-	-	-	-	-	-	-	-	-
Quercus acutissima	-	100	-	33,33	-	-	4,44	0,74	-	-	-	-	-	-	18,15	3,03	-	-	3,90	0,65	-	-	20,0	3,33
Quercus dentata	-	-	-	-	-	-	-	-	-	-	-	-	-	30,00	12,45	12,08	-	-	-	-	-	-	-	-
Quercus liena	-	-	1,98	0,33	-	-	-	-	-	-	5,67	0,95	-	-	-	-	6,17	-	28,10	7,77	-	-	-	-
Quercus mongolica	-	-	-	-	-	-	54,21	9,04	-	20,47	18,90	9,97	-	-	-	-	7,56	18,03	25,32	14,01	-	-	-	-
Quercus serrata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2,02	0,34	-	-	-	-
Cocculus trilobus	-	-	0,92	0,15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	70,0	11,67
Spiraea prunifolia for. simpliciflora	-	-	1,20	0,20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stephanandra incisa	-	-	1,20	0,20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sorbus alnifolia	-	-	1,24	0,21	-	-	-	-	-	-	-	-	-	-	-	-	-	81,97	-	27,32	-	-	-	-
Rubus crataegifolius	-	-	1,43	0,24	-	-	0,98	0,16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10,0	1,67
Rosa multiflora	-	-	-	-	-	-	-	-	-	-	7,56	1,26	-	-	-	-	-	-	-	-	-	-	-	-
Prunus sargentii	-	-	-	-	-	-	-	-	-	6,78	-	2,26	6,95	18,01	13,00	11,65	-	-	3,90	0,65	-	-	-	-
Lespedeza cyrtobotrya	-	-	38,32	6,39	-	-	6,98	1,16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pueraria thunbergiana	-	-	40,73	6,79	-	-	-	-	-	-	-	-	-	-	-	-	-	--	-	-	-	-	-	-
Indigofera kirilowii	-	-	1,11	0,19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Robinia pseudo-acacia	-	-	-	-	-	7,41	15,98	5,13	100	72,76	-	74,25	7,28	28,29	4,98	13,90	-	-	-	-	-	-	-	-
Zanthoxylum schinifolium	-	-	0,87	0,15	-	-	5,55	0,93	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Securinega suffruticosa	-	-	1,75	0,29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhus chinensis	-	-	4,07	0,68	-	-	1,98	0,33	-	-	-	-	-	-	6,50	1,08	-	-	10,08	1,68	-	-	-	-
Aralia elata	-	-	1,61	0,27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhododendron mucronulatum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20,86	3,48	-	-	-	-
Symplocos chinensis for. pilosa	-	1,24	-	0,21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5,83	0,97	-	-	-	-
Clerodendron trichotomum	-	-	-	-	-	-	5,95	0,99	-	-	-	-	-	-	15,03	2,51	-	-	-	-	-	-	-	-
Viburnum erosum	-	-	-	-	-	-	-	-	-	-	4,11	0,69	-	-	-	-	-	-	-	-	-	-	-	-
Smilax sieboldii	-	-	9,89	1,65	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

[a]: Canopy layer importance value; [b]: Understory layer importance value; [c]: Shrub layer importance value; [d]: Mean importance value

mongolica(I.V.: 14.5%) were mainly observed in the canopy layers of the *Capinus laxiflora* community, and *Capinus laxiflora, Rhododendron mucronulatum, Sorbus alnifolia*, and *Prunus sargentii* were distributed in its understory layers. The dominant distribution of *Rhododendron mucronulatum*(I.V.: 61.55%) was observed, and *Quercus mongolica* and *Rhus trichocarpa* also appeared.

Indiscreet cutting-down has been done in the *Castanea crenata* community and *Capinus laxiflora* community, resulting in a simple composition of 4 species in the herbaceous layers. Specifically, sporadic paths up the mountain have caused severe damage to *Capinus laxiflora*, which is a rare climax species in Seoul, raising urgent needs for protection measures.

The *Pinus densiflora* community has been divided into lowland type and slope types. We have observed well-preserved *Pinus densiflora* with wide

Table 4. Dominance and sociability of herbaceous plants in Seoo Royal Tomb urban natural park

Species name	*Quercus acutissima (lowland)*		*Quercus acutissima (valley)*		*Quercus variabilis*		*Quercus mongolica*		*Castanea crenata*		*Capinus laxiflora*	
	D[a]	S[b]	D	S	D	S	D	S	D	S	D	S
Pteridium aquilinum var. *latiusculum*	-	-	+	1	-	-	1	2	+	1	-	-
Oplismenus undulatifolius	1	2	-	-	1	2	-	-	-	-	+	1
Spodiopogon sibiricus	+	1	+	1	1	2	+	1	r	1	1	2
Carex humilis	r	1	+	1	+	1	+	1	+	1	+	1
Carex siderosticta	-	-	1	2	-	-	-	-	-	-	-	-
Commelina communis	r	1	-	-	-	-	-	-	-	-	-	-
Hemerocallis fulva	-	-	-	-	-	-	+	1	-	-	-	-
Disporum smilacinum	-	-	3	3	-	-	-	-	-	-	-	-
Liriope platyphylla	+	1	-	-	-	-	-	-	-	-	-	-
Convallaria keiskei	-	-	+	1	-	-	-	-	+	1	-	-
Persicaria perfoliata	-	-	-	-	r	1	-	-	-	-	-	-
Persicaria hydropiper	r	1	-	-	-	-	-	-	-	-	-	-
Chenopodium album var. *centrorubrum*	r	1	-	-	-	-	-	-	-	-	-	-
Carastium holosteoides var. *hallaisanense*	+	1	-	-	-	-	-	-	-	-	-	-
Sedum sarmentosum	+	1	-	-	-	-	-	-	-	-	-	-
Viola verecunda	r	1	+	1	-	-	-	-	-	-	-	-
Pyrota japonica	-	-	+	1	-	-	-	-	-	-	-	-
Phryma leptostchya var. *asiatica*	+	1	-	-	-	-	-	-	-	-	-	-

(Table 4. continued)

Species name	*Pinus densiflora (lowland)*		*Pinus densiflora (slope)*		*Robinia pseudo-acacia*		Populus × albaglandulosa		*Pinus rigida*		*Pinus koraiensis*	
	D[a]	S[b]	D	S	D	S	D	S	D	S	D	S
Pteridium aquilinum var. *latiusculum*	1	2	-	-	r	1	-	-	-	-	+	1
Oplismenus undulatifolius	-	-	-	-	2	2	-	-	-	-	+	1
Miscanthus sinensis	r	1	-	-	-	-	-	-	-	-	-	-
Spodiopogon sibiricus	r	1	3	3	1	2	2	2	+	1	+	1
Carex humilis	+	1	r	1	-	-	r	1	-	-	+	1
Carex siderosticta	-	-	-	-	-	-	-	-	-	-	-	-
Commelina communis	+	1	-	-	r	1	-	-	-	-	-	-
Hemerocallis fulva	-	-	-	-	-	-	-	-	-	-	-	-
Disporum smilacinum	-	-	-	-	-	-	-	-	-	-	-	-
Liriope platyphylla	-	-	-	-	-	-	-	-	-	-	-	-
Convallaria keiskei	-	-	-	-	-	-	-	-	1	2	-	-
Humulus japonicus	+	1	-	-	-	-	-	-	-	-	-	-
Persicaria perfoliata	-	-	-	-	-	-	-	-	-	-	-	-
Persicaria thunbergii	3	3	-	-	-	-	-	-	-	-	-	-
Persicaria hydroniper	-	-	-	-	-	-	-	-	-	-	-	-
Chenopodium album var. *centrorubrum*	-	-	-	-	-	-	-	-	-	-	-	-
Carastium holosteoides var. *hallaisanense*	-	-	-	-	-	-	-	-	-	-	-	-
Oxalis corniculata	-	-	-	-	r	1	-	-	-	-	-	-
Viola verecunda	-	-	-	-	r	1	-	-	-	-	-	-
Pyrota japonica	-	-	-	-	-	-	-	-	-	-	-	-
Phryma leptostachya var. *asiatica*	-	-	-	-	-	-	-	-	-	-	-	-
Ambrosia artemisiifolia var. *elatior*	+	1	-	-	-	-	-	-	-	-	-	-
Ambrosia trifida	2	2	-	-	-	-	-	-	-	-	-	-
Artemisia princeps var. *orientalis*	1	2	-	-	-	-	-	-	-	-	-	-

[a]: Dominance; [b]: Sociability

a: *Quercus acutissima*-vally

b: *Quercus acutissima-disporum* simlacinum

Photo 1. Vegetation status of *Quercus acutissima* community (valley)

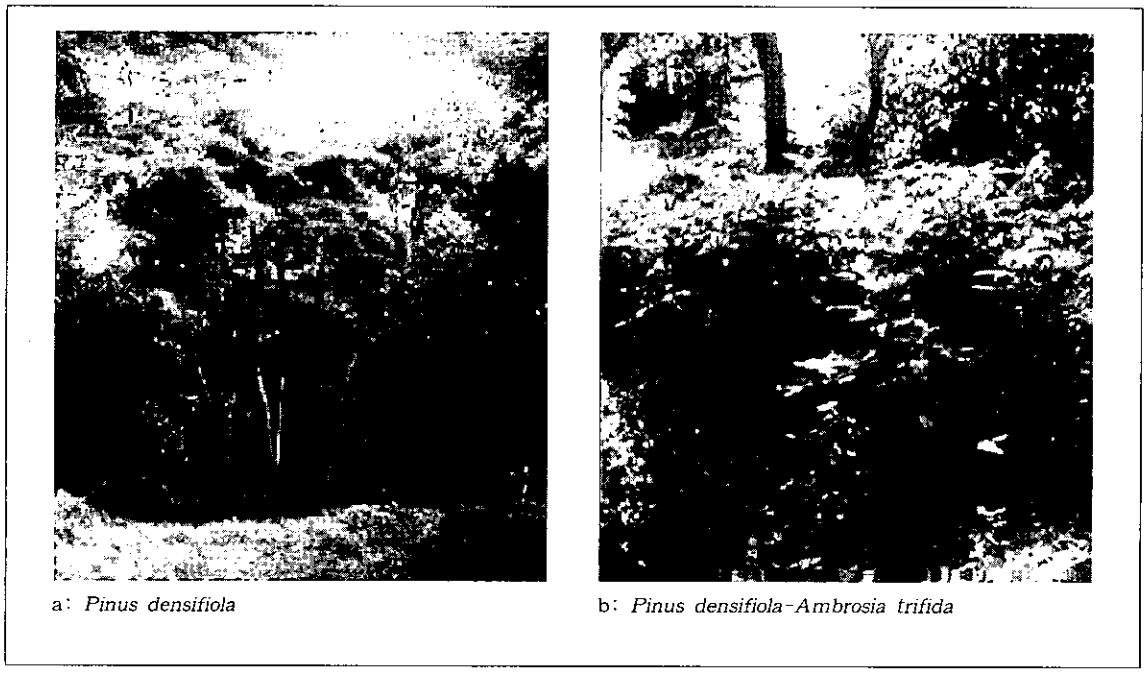
c: *Castanea crenata*

d: *Capinus laxiflora*

Photo 2. Vegetation damage status of *Castanea crenata* and *Capinus laxiflora* community

diameters in the lowlands, where *Pinus densiflora* was predominant in the canopy layers and *Quercus acutissima* was superior in the understory layers. In the shrub layers, *Pueraria thunbergiana*(I.V.: 40.73%) and *Lespedeza cyrtobotrya*(I.V.: 38.32%) were predominant, and *Smilax sieboldii, Rhus chinensis, Quercus aliena*, and *Securinega suffruticosa* composed a secondary species group. *Pinus densiflora* was predominant in the layers of canopy and understory of the slope-type *Pinus densiflora* community, and it is expected that the community will maintain its current conditions. On the other hand, *Quercus mongolica*(I.V.: 54.21%) has been spreading out its territory in the shrub layers, and the layers are expected to be succeeded by *Quercus mongolica*. As for the herbaceous layers, *Persicaria thunbergii* was predominant in the lowland-type *Pinus densiflora* community, but the spreading of naturalized species such as *Ambrosia artemisiifolia* var. *elatior* and Ambrosia trifida (Photo 3) is expected.

Ambrosia artemisiifolia var. elatior and *Ambrosia trifida* were designated as hazardous exotic species by the Natural Environment Conservation Law in the year 1999. That is, those two species are widely known as a source of a disease called pollinosis, which is related to allergic rhinitis caused by pollen and is an issue in the US, the place of origin, and Japan. Currently, however, it is very difficult to understand the effects of naturalized plants on the forest ecosystem of the country(Lee, 1999). Most naturalized plants such as *Ambrosia artemisiifolia* var. *elatior*, *Trifolium repens*, and *Taraxacum officinale* are distributed as a group in roadsides or bare ground with a high rate of light and in upper canopies with low coverage rates, indicating that light is one of determinant factor for the ecological characteristics of plants. In



a: *Pinus densifiola* b: *Pinus densifiola-Ambrosia trifida*

Photo 3. Vegetation status of *Pinus densiflora* community (lowland)

other words, microenvironments such as light, temperature, and humidity are known to restrict the colonization of naturalized plants(Brothers and Spingarn, 1992; Groves and Burdon, 1986). In the case of *Ambrosia trifida* of the *Pinus densiflora* community, the species was forming such a large community under the cover of *Pinus densiflora* or in the valleys with a scant supply of light that consistent monitoring and management need to be performed to observe its change.

As for the *Robinia pseudo-acacia* community, an artificial forest, relative dominance values of *Robinia pseudo-acacia*, a dominant species, were 100% and 72.76% in the layers of canopy and understory respectively, but the dominance of *Quercus mongolica* was considerable in the layers of understory(I.V.: 20.47%) and shrub(I.V.: 18.9%), suggesting future spreading. Similar trends have been observed in the *Populus*×*albaglandulosa* community: *Populus*× *albaglandulosa* was predominant in the canopy layers, but the relative dominance values of *Quercus dentate* were 30% and 12.45% in the layers of understory and shrub, respectively. In addition, as for the *Pinus rigida* community, as the dominance of *Quercus mongolica* and *Quercus aliena* in the layers of understory and shrub has gotten stronger, the natural selection of *Pinus rigida* has occurred, suggesting future succession into *Quercus* spp. The *Pinus koraiensis* community was composed of a single species of *Pinus koraiensis,* resulting in a mono-layer structure. The herbaceous plants of the artificial forest showed simple species compositions: the number of species ranged from 2 to 6 species, and *Spodiopogon sibiricus* was predominant.

3) Diversity index

Shannons diversity index(H') of each vegetation type ranged from 0.4554 to 0.9287, and the maximum diversity index(H'max) ranged from 0.6021 to 1.2553. The diversity indexes of 1.0 or above represent that there have been less human disturbances and better environment conditions have been maintained(Lee, *et al.*, 1993). The diversity indexes of Seoo Royal Tomb, which is an urban natural park, were relatively low because the forest has been influenced by human disturbances, air pollution, and acid rain.

The diversity index is regarded as a criterion that explains the stability of plant communities (Brower and Zar, 1977). The index value of the

Table 5. The values of diversity indices in Seoo Royal Tomb urban natural park

Vegetation types	Shannon(H')	Evenness(J')	Dominance(D)	H'max
Quercus acutissima (lowland)	0.8332	0.8332	0.1668	1.0000
Quercus acutissima (valley)	0.8637	0.8294	0.1706	1.0414
Quercus variabilis	0.9287	0.8337	0.1663	1.1139
Quercus mongolica	0.6897	0.7228	0.2772	0.9542
Castanea crenata	0.7770	0.8143	0.1857	0.9542
Capinus laxiflora	0.6644	0.7861	0.2139	0.8451
Pinus densiflora (lowland)	0.8200	0.6532	0.3468	1.2553
Pinus densiflora (slope)	0.4554	0.5853	0.4147	0.7782
Robinia pseudo-acacia	0.7157	0.8468	0.1532	0.8451
Populus× *albaglandulosa*	0.7585	0.8399	0.1601	0.9031
Pinus rigida	0.8708	0.8362	0.1638	1.0414
Pinus koraiensis	0.5022	0.8342	0.1658	0.6021

Quercus variabilis community at Seoo Royal Tomb was 0.9287, implying that the urban natural park has advanced into a stable stage. But the index value of the *Capinus laxiflora* community on which human interferences have been seriously inflicted recorded 0.6644.

This result coincides with another study conclusion that the diversity index of a forest where

vegetation and species structures are not stable through shrub cutting work recorded 0.6 or below(Lee, *et al.*, 1995). In particular, the *Capinus laxiflora* community is one of the climax species observed in the country, and thus special conservation measures should be taken for this species.

The *Robinia pseudo-acacia* community, *Pinus rigida*, and *Populus×albaglandulosa* community, which are regarded as artificial forests, have been competing with *Quercus* spp. such as *Quercus mongolica* and *Quercus dentate*, with their diversity indexes ranging from 0.7157 to 0.8708. This result is congruent with a research conclusion(Odum, 1992) that the diversity index of disturbed ecosystems, such as artificial forests, tends to increase at their initial succession stage as their succession proceeds.

IV. CONCLUSIONS AND SUGGESTIONS

Vegetation of Seoo Royal Tomb, a urban natural park has been classified into 12 types, and they include: *Quercus acutissima* community(lowland type), *Quercus acutissima* community(valley type), *Quercus variabilis* community, *Quercus mongolica* community, *Castanea crenata* community, *Capinus laxiflora* community, *Pinus densiflora* community(lowland type), *Pinus densiflora* community(slope type), *Robinia pseudo-acacia* community, *Populus×albaglandulosa* community, *Pinus rigida* community, and *Pinus koraiensis* community. Based on the survey and analysis results, we have classified the study area into conservation, buffer, and utilization zones for effective management. The conservation zone is broken down into the *Quercus acutissima* community(valley type), *Quercus variabilis* community, *Quercus mongolica* community, *Capinus laxiflora* community, and *Pinus densiflora* community(lowland type); the buffer zone is broken down into the *Robinia pseudo-acacia* community, *Populus×albaglandulosa* community, *Pinus rigida* community, and *Pinus densiflora* community(slope type); and the utilization zone is broken down into the *Pinus koraiensis* community, *Castanea crenata* community, and *Quercus acutissima* community(lowland type).

1) The forest ages of the *Quercus acutissima* community(valley type), *Quercus variabilis* community, and *Quercus mongolica* community, which belong to the conservation zone, were more than 20 years. Especially, the *Capinus laxiflora* community, which is a rare climax species in Seoul, was distributed on the slopes with a high degree of 20. Its forest ages ranged from 15 to 17, belonging to the young forest but the rare species is believed to be worth preserving. The *Pinus densiflora* community with 35~50 cm DBHs was distributed in the lowlands around Tapgol mineral spring forming good landscape, and its forest age varied from 40 to 70. Therefore, a cultural landscape centering on Pinus densiflora may be displayed in this area. The selection of *Persicaria thunbergii,* however, is also forecasted because *Ambrosia trifida*, a naturalized species, is aggressively occupying its habitats as a group. To prevent the spreading of *Ambrosia trifida* and restore naturalness, measures for ecological management and competitive species need to be taken in the future.

2) The buffer zone consists of artificial forests and includes the *Robinia pseudo-acacia* community, which shows over 20 years old forest and has been competing with the *Quercus* spp., *Populus×albaglandulosa* community, and *Pinus*

rigida community. On the slopes, the *Pinus densiflora* community was distributed on a small scale and is expected to be placed under unfavorable conditions, facing competition by *Quercus* spp. including *Quercus mongolica* of the shrub layers. Thus, management activities such as selective thinning work need to be performed to promote ecological succession in the buffer zone community.

3) The *Pinus koraiensis* community, *Castanea crenata* community, and *Quercus acutissima* community(lowland type) belong to the utilization zone and are situated in the lowlands around residential areas, exposed to human interferences such as waste, offensive odors, and reckless thinning work. In this regard, appropriate management for recreation spaces and paths up the mountain should be established.

This study provides basic data to support the establishment of master plans for urban natural parks by analyzing vegetation conditions at Seoo Royal Tomb, an urban natural park. Based on the results presented in the study, consistent monitoring work needs to be conducted, and elaborate management plans also should be prepared. In relation to wise utilization, an environmental education program needs to be developed while meeting various local residents needs of sports, recreation, and education, while also preserving the natural asset.

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