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Vegetation Management Units and Its Landscape Structures of Mt. Cheolma, in Incheon City, Korea

Cho, Hyun-Je[1]* and Je-Hyung Cho[2]

[1]*Department of Forest Resources & Biotechnology, Daegu Polytechnic College, Daegu 706-711, Korea*
[1]*Department of Forest Ecology, Forestry Research Institute, Seoul 130-012, Korea*

ABSTRACT: For landscape ecological management of the isolated forestlands in Incheon city located in the western tip of South Korea, the forest vegetation of Mt. Cheolma was classified phytosciologically and mapped out its spatial distribution at a scale of 1:5,000. Characteristics of forest landscape structures were discussed in terms of the number and size of patches obtained by analy zing vegetation map. Units to manage the forest vegetation were categorized into eighteen communities, seventeen groups, and sixteen subgroups. Landscape elements were classified into five types: secondary vegetation, introduced vegetation for forestry (IVF), introduced vegetation for agriculture (IVA), and other elements. Two hundred and ninety-three forest landscape patches covers 443.3ha, of which IVF accounted for 316.8ha(71.5%), the largest portion, secondary vegetation for 101.2ha(22.8%), IVA for 6.2ha(1.4%), and others for 19.1ha(4.3%). The ratio of natural forest elements of 31.9% showed that this area was mainly comprised of artificially introduced vegetation, such as *Robinia pseudoacacia* plantation and *Pinus rigida* plantation. Forest landscape patches have a mean area of 4.5ha, a density of 66.1/100ha, and a diversity index of 0.87. It was estimated that differentiation of patches recognized in community level would be related to human interference and those in subordinate level to natural processes.

Key words: Ecological management, Forest vegetation management units, Landscape element, Patch density, Spatial distribution, Vegetation map

INTRODUCTION

Urban forest is essential for visual amenity and landscape enhancement and for ecosystem services - the functions performed by ecosystems that on sure natural cycles continue to provide an environment conducive with quality of life, including human life. Consequently, the management of urban forest areas is an increasingly important issue. Generally, forest ecosystem of the urban area becomes simpler in function and composition and fragmented in size as one approach the urban core where human influences increase. Isolated fragments in an urban environment often are too small to sustain populations of species for very long. Forest communities form in a slow process of succession and are very sensitive to environmental conditions.

International attention to forest and forestry has recently focused on degradation and protection of the urban forest. The forest in the urban core is usually isolated and has a low biodiversity in comparing with that of the mountain area. There is a need to shift the focus from individual trees to the management of the urban ecosystem, and to manage urban forest as a significant part of this ecosystem. Therefore, It is very important to assess and classify forest vegetation, the most representative components for restoration and maximization of the ecological function in the urban forest with minimizing costs in the view of forest ecology. The spatial distribution map separated by the vegetation units in detail also needs (Burgess 1981, Cho *et al.* 1995). A detailed vegetation mapping provides the information for a tool and methods available to look at, study and map the forest resources in cities (Küchler 1967, Hampe 1982, Toyo-hara 1984, Duhme and Pauleit 1998). However, in our country, there have been no ecological units to manage urban vegetation and to conserve its diversity. Moreover our ecologists have been reluctant in studying urban nature because it has been regarded as less worthy than non-urban nature, and therefore there are few reports quantifying and mapping in detail of urban forest and its landscape structures in our country (Lee *et al.* 1995, Cho 1997, Cho *et al.* 1999).

For these reasons, the main aims of this study are to classify and map in detail the forest vegetation units of Mt. Cheolma, the most representative isolated forestland, Incheon city and discuss its landscape structures with special reference to ecological management.

* Author for correspondence; Phone: 82-53-749-7280, Fax: 82-53-758-5897, e-mail: jhi132@chollin.net

STUDY AREA AND METHODS

The study area chosen is located in the western part of Incheon city, Korea. It lies at longitude 126° 40′ 48″ to 126° 42′ 27″ east and latitude 35° 31′ 46″ to 35° 27′ 53″ north, and attains a height of 195m at elevation. Its forest area is about 443.3ha. Incheon' s climate is characterized by long daylight hours and relatively dry weather. As a maritime city, Incheon is subject to the seasonal winds and fickle local wind. The average temperature is 11.4℃ and the annual temperature variation is 28.0℃. The amount of rainfall is rather small compared with other regions in the central and southern parts of the Korean peninsula. The annual precipitation amounts to 1,170.1mm and the number of rainy days is 101.7 days(KMA 2000).

Most of the forests are secondary forests and artificial plantations, which have been strongly influenced by human activities. *Robinia pseudo-acacia* forest, *Pinus rigida* forest, and *Q. mongolica* forest is a representative of plant communities. Most of the understory vegetation comprises initial species in succession stage. The vegetation survey studied in the study area from April 2001 to November 2001 by the method of the ZM School. In all, about 326 plots were chosen subjectively on a reconnaissance basis. Homogeneity in terms of physiognomy and local conditions as well as the representatives of the habitats was considered as prerequisites for selected plots. At each plot, all vascular plants listed with the abundance-cover and sociability. Nomenclature of species followed Lee (1985). The categorization on forest vegetation units is based on floristic-structural releves, which were established using the floristic-physiognomic approach introduced by Braun-Blanquet (Braun-Blanquet 1964, Muller-Dombois & Ellenberg 1974). Vegetation units graded community in the higher unit, group in the lower unit, and subgroup in the lowest unit. The upper units based on physiognomy and rarity of forest plant communities. The middle and lower units based on species composition and structure. The more detail vegetation map at a scale of 1:5,000 was made by field survey. Vegetation units assessed and delineated its spatial distribution on the detailed vegetation map in terms of the landscape ecology. The minimum mapping unit was 0.5ha for forest landscape element. Using these maps, we summarized patch type, area, number, and density and also calculated a landscape diversity index based on the Shannon-Wiener information theory index (Shannon and Weaver 1962), which describe overall landscape structure (Turner and Ruscher 1988). The patch density (PD) is calculated as: PD=n/a where n and a is number of patches and Area, respectively.

RESULTS AND DISCUSSION

Classification of the forest vegetation management units

Three hundreds and twenty-six records were collected from various parts of the forest vegetation in this area. The study area is largely covered with artificially induced vegetation and some naturally regenerated vegetation. Based on the phytosociological data obtained by the method of ZM School, The forest vegetation management units can be divided into eighteen communities with correspond to the association or rare and imperiled community, and they are further subdivided into seventeen groups which correspond to the subassociation, and fourteen subgroups which correspond to the variants (Table 1). A description of the vegetation units and their subordinate units is made as follows.

· Naturally regenerated vegetation: eight communities with nine groups and five subgroups

Quercus mongolica(QUMO) community is distinguished from other communities by the presence and dominance of the differential species group 1,10,16 and 18. This is further divided into two lower units of *P. densiflora* group and *Athyrium yokoscense - Robinia pseudo-acacia* group having five subgroups. *Sorbus alnifolia*(SOAL) community is distinguished from other communities by the presence and dominance of the differential species group 5 to 8. This is further divided into three lower units of *Smilax sieboldii - Styrax japonica* group, *Alnus hirsuta* group *and Disporum* viridescens group. *Q. variabilis*(QUVA) community is distinguished from other communities by the presence and dominance of the differential species group 9. *Pinus densiflora*(PIDE) community is distinguished from other communities by the presence and dominance of the differential species group 6, 10, 11, and 35. This is further subdivided into two lower units of *Sorbus alnifolia* group *and Diodia teres - Rhododendron mucronulatum* group. *Quercus serrata*(QUSE) community is distinguished from other communities by the presence and dominance of the differential species group 3,5,6,12, and 34. This is further subdivided into two lower units of *Smilax china - Q.dentata* group and *S. japonica - S. alnifolia* group. *Q. acutissima*(QUAC) community, *Fraxinus rhynchophylla*(FRRH) community, and *Picrasma quassioides*(PIQU) community are distinguished from other communities by the presence and dominance of the differential species group 13, 14, and 15, respectively.

· Artificially introduced vegetation: ten communities with eight groups and eleven subgroups

Robinia pseudo-acacia(ROPA) plantation is distinguished from other communities by the presence and dominance of the differential species group 4,5,8,9,13,16,18,20,21,22, and 26. This is further subdivided into four lower units of *Oplismenus undulatifolius - S. japonica* group, *Stephanandra incisa - Q. variabilis* group, *Lespedeza bicolor* group, *and Q. variabilis* group having six subgroups. *P. rigida*(PIRI) plantation is distinguished from other communities by the presence and dominance of the differential species group 18, 23, and 27. This is further subdivided into two lower units of *Melica onoei - Cocculus triobus* group hav-

Table 1. Floristic composition table of forest vegetation management units of Mt. Cheolma in Incheon City, Korea

I *Quercus mongolica* community
I-A *Pinus densiflora* group
I-A-1 *Spodiopogon sibiricus* subgroup
I-A-2. Typical subgr.
I-B *A. yokoscense - R. pseudoacacia* gr.
I-B-1 *Stephanandra incisa* subgr.
I-B-2 *S. chinensis* var. *oblosa - Q. dentata* subgr.
I-B-3. Typical subgr.
II *Sorbus alnifolia* community
II-A *Smilax sieboldii - Styrax japonica* gr.
II-B *Alnus hirsuta* gr.
II-C *Disporum viridescens* gr.
III *Quercus variabilis* community
IV *Pinus densiflora* community
IV-A *Sorbus alnifolia* gr.
IV-B. *Diodia teres - R. mucronulatum* gr.
V *Quercus serrata* community
V-A *Smilax china - Q. dentata* gr.
V-B *S. japonica - S. alnifolia* gr.
VI *Quercus acutissima* community
VII *Fraxinus rhynchophylla* community
VIII *Picrasma quassioides* community
IX *Robinia pseudoacacia* plantation
IX-A *Oplismenus undulatifolius - S. japonica* gr.
IX-A-1 *A. yokoscense* subgr.
IX-A-2 *Q. acutissima* subgr.
IX-B *S. incisa - Q. variabilis* gr.
IX-C *Lespedeza bicolor* gr.
IX-C-1 *M. oblongistachyus* var. *longibarbis - Q. serrata* sub
IX-C-2. Typical subgr.
IX-D *Q. variabilis* gr.
IX-D-1 *C. communis - R. crataegifolius* subgr.
IX-D-2 *Populus tomentiglandulosa* subgr.
X *Pinus rigida* plantation
X-A *M. onoei - C. trilobus* gr.
X-A-1 *S. chinensis* var. *oblosa - Q. aliena* subgr.
X-A-2. Typical subgr.
X-A-3. *R. crataegifolius - Z. schinifolium* subgr.
X-B *A. yokoscense - C. crenata* gr.
X I *P. tomentiglandulosa* plantation
X I-A *A. yokoscense - J. rigida* gr.
X I-B Typical gr.
X II *Castanea crenata* plantation
X III *Alnus hirsuta* plantation
X IV *Larix leptolepis* plantation
X V *Pinus koraiensis* plantation
X VI *Pinus thunbergii* plantation
X VII *A. altissima* plantation
X VIII *Abies holophylla* plantation

No.	Vegetation management units / Community no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	Constancy	No. of plots
	Naturally regenerated vegetation / Artificially induced vegetation	Natural: Mountain areas														Natural: Lowland & Depression areas			Artificial																								
	Unit	I						II			III	IV		V		VI	VII	VIII	IX								X				X I		X II	X III	X IV		X V	X VI	X VII	X VIII	X IX		
	Group	A			B			A	B	C		A	B	A	b				A			B	C		D		A			B													
	Subgroup	1-a	1-b	2	1	2	3												1	2-a	2-b		1	2	1	2	1	2	3		1	2			1	2							
	Canopy tree	QUMO	QUMO	QUMO	QUMO	QUMO	QUMO	SOAL	SOAL	SOAL	QUVA	PIDE	PIDE	QUSE	QUSE	QUAC	FRRH	PIQU	ROPA	ROPA	ROPA	ROPA	ROPA	ROPA	ROPA	ROPA	PIRI	PIRI	PIRI	PIRI	POTO	POTO	CACR	ALHI	LALE	LALE	PIKO	PITH	AIAL	ABHO	PIAB		
	Average no. of species occurred	14	14	7	16	14	11	12	10	10	13	20	15	14	9	7	20	24	16	17	17	10	13	8	17	8	19	12	17	12	15	9	13	17	7	20	10	1	10	13	1		
	Total no. of species occurred	30	24	9	35	34	25	21	17	10	21	21	24	26	19	6	20	11	41	38	34	21	24	16	28	6	34	35	31	24	28	21	30	33	9	29	13	7	6	9	2		
	No. of relevés	7	8	2	15	13	8	4	5	2	4	3	5	6	5	1	3	1	50	28	18	6	7	5	8	3	8	31	11	7	8	4	9	7	3	3	4	2	1	1	1		
	Differential species groups																																										
1	*Quercus mongolica*	V 52	V 41	2 50	V 38	V 49	V 31	3 11	V 18	2 +	3 24	3 28	V 26	V 14	V 12		3 +	0	V 6	IV 4	IV 8	V 6	IV 6	II 4	V 2		IV 6	V 12	V 9	V 15	IV 8	2 +	IV 12	V 10		3 8	2 0	2 10				V	262
2	*Juniperus rigida*	V 2			III 5	II 0	III 2	1 0	I 0		1 0	3 3	III 0	III 3	II 0				II 1	I 0	II 0		II 0				III 0	II 0	III 0	III 0	IV 3		II 0	II 0		2 0						II	88
3	*Quercus dentata*	II 0	V 8		III 4	II 5	II 3	1 0	I 0			3 6	III 8	V 8					III 2	V 6	IV 5	I +	II 0	I 0	V 1		III 4	III 1	IV 5	II 4	IV 7	2 4	II 0	III 6		1 +	2 4					III	151
	Pteridium aquilinum var. *latiusculum*	I 0	IV 0										I 0								I 0		I 0					I 0						I 0								R	13
4	*Stephanandra incisa*	I 0	I 0		V 6	I			II 4	1 +	2 0	1 +	I 0		I +		2 0	0	R 19	R 0	I 0	III 3			I +				I 0	I 0	II 9		II 13	I +		1 0	1 38					II	96
5	*Styrax japonica*	I 18			I 0	V 14		4 10	I +	1 +	3 5			I 18	III 25	18	1 +		III 4	III 5	V 12	II 19	I 18		I 0		IV 3	II 4	I 4	III 18	II 13	1 +	III 9	V 8				1 5				II	117
	Symplocos paniculata				II 0	III 3	II 0	1 0	I 0		2 0				I 0		1 0		III 1	III 1	II 0	II 0			I 0		V 1	I 0	I 0	II +	II 3	2 0	II 0	II 0	1 0	1 0						II	93
6	*Sorbus alnifolia*	IV 3	II +	1 18	IV 13	IV 10	III 31	4 56	V 48	2 68	4 4	2 +	I +		V 7		1 +		II 2	II 3	III 2	III 32	I 0				II 0	II 9	I +	II 13	II 63		IV 6	III 6		2 19						II	124
7	*Smilax sieboldii*	I +	I 0		II 0	I 0	I 0	3 3		1 +		1 0					3 0		I 1	I 0	I 0	II 0					I 0		I 0	I 0	II 0		I 0	III 0	1 0	2 0		2 10			0	I	48
8	*Disporum viridescens*				I +					2 13												I 18									II 63		I 18	I 0		1 18						R	10
9	*Quercus variabilis*	I +				I +					4 44			I +	I +	8			II 10	R 0		III 13	I +	1 63	III 4	3 25	II 9	I 5	II 5	I 18	II 11	1 +	III 18		1 0	2 19				8		I	17
	Prunus leveilleana	I +			I 0	I +					3 3				I +				I 1	I 0	II 2				I 0		I 0	I 0			I 0		II 5			1 0						I	32
10	*Pinus densiflora*	V 13	V 10	2 23		II 0		1 +			1 0	3 54	V 30	II 9	II 4	8			R 0						II 4		II 4	II 6	II 11		II 0		I +	I +								I	56
	Arundinella hirta	III +	II 3		I 0	I 0						3 0	IV 6						R 0	I 0	I 3		II 0	II 28	IV 6	1 +	I 0	I 0	I +	I 0				I 0			1 +		63	38		I	42
	Themeda triandra var. *japonica*	I 0										2 0	III 5																													R	6
11	*Diodia teres*	I 0											III 3																													R	4
12	*Quercus serrata*	III 5	II +	1 18	III 9	IV 10	IV 16	2 +			1 +	2 0	III 5	V 28	V 48	8	3 5		IV 1	IV 6	IV 15		V 11		V 6		V 12	V +	V 10	III 4	IV 10	1 +	III 6	V 16		1 +		2 +				IV	206
13	*Quercus acutissima*		I +			I +	II +							III 8	I 38	38			I 4	III 4	IV 5		III 3		II 4		III +	II 5	III 5	I 0	II 4	2 13		III 6		1 0		1 0				II	69
14	*Fraxinus rhynchophylla*	I +	II +		I +	I 4			I 18	1 +					I +		3 54		R 0			I +					I 0		I 0	I 0	I 0		II 4									I	22
	Lindera obtusiloba				II 5	II 5	I 0	1 0	II 0	2 0							2 +	18	I 0			II 0								II 0		1 0	III 6	II 0		2 0						I	37
	Callicarpa japonica	I 0	I 0			I 0			I 0			1 +	I 0	II 0			2 4	0	II 0								I 0	I 0		I 0			II 0	I +								I	32
15	*Picrasma quassioides*																1 0	63																									
	Tilia amurensis								I +								1 0	18		R 0																1 0						R	5
	Crataegus pinnatifida				I 0													8																								R	2
16	*Robinia pseudo-acacia*	I +			IV 7	V 5	IV 3	1 0	II 0		1 +		I 0	V 7	V 6	18	1 +		V 58	V 60	V 60	V 63	V 33	V 30	V 75	3 38	V 11	V +	IV 10	V 6	IV 11	3 14	II 18	V 11	3 14	3 +	4 13	1 +	8	18		IV	248
17	*Oplismenus undulatifolius*				I 0	I 0		1 0						II 0				0	IV 2	IV 10	IV 4	I 18			I +		III 0	I 0	I 0	III 0	I 0	1 0	I 0	III 0								II	95
18	*Spodiopogon sibiricus*	III 4	V 4		II 0	II 0	II 3				3 0	1 +	II 4	III 4	I +				III 2	II 1	II 0	I 0	I 0		V 3			II 1	II 11	I 0	I 0	2 0	II 0	I 0		1 +						II	125
	Athyrium yokoscense			1 0	IV 3	IV 5	III 2	2 4	III 3	2 0	1 18				II 0		2 0	0	IV 3		I 0	II +					II 4	I 0	I 0	V 4	IV 3		III 0	III 4	1 0	3 3	1 0					II	104
19	*Quercus aliena*					I 0		1 0				1 0		II +	I +				I 3	IV 6	II 5		I 0				III 2	I 0	I 0		I +	1 0		I 0								I	48
	Commelina communis																		II 1	III 2	I 0	I +			IV 2		II 0	I 0			I 0	1 +	I 0			1 0				0		I	48
	Persicaria perfoliata																		I 2	IV 2	I 0		I 0		II 0			R 0							1 0							I	30
20	*Lespedeza bicolor*	IV 5	V 12	1 +	II 4	I 18	III 14				2 13		V 14	III 25					II 3	II 3	II 5		V 28	V 25	I 0		II 3	II 1	V 14	I 0	II 3		I 0	I +		1 0	2 9		0			II	104
21	*longibarbis*	I 0	I 0	1 0	I +	I 0	II 0				I 0		II 0	I 0					I 0	I 0	II 0		IV 7	I 0			I 0	R 0	II 2					II 0								I	38
22	*Rubus crataegifolius*		I 0		I 4	I 0								I 0					I 2	II 2	I 0	I 0	II 0	II 4	IV 7		I 0	I 0	IV 0			1 0	II 0			1 0	1 18			8		I	53
23	*Pinus rigida*	IV 5	IV 11	1 +	II 6	III 5	IV +	2 13	II 4	2 +	2 +	1 0	IV 13	III 11	I +		2 4		I +	II 5	III 6	III +	IV 10	III 5	I +		V 56	V 71	V 33	V 52	II 4	1 +	II +	V +		1 +						III	160
24	*Cocculus trilobus*	III 3	IV 0	1 0	II 0	I 4	II 0				2 0	3 3	IV 2	II +	II 0				III 0	IV 0	IV 1		IV 0	II 4	II 0		IV 1	III 0	V 4		II 0		II 0	III 0	1 0	2 0	2 0		0			III	139
	Melica onoei	I 0	II 0		II 0	I +		1 0				1 0		I 0			1 0		IV 1	IV 3	IV 2		I 0		V 10		IV 2	III 1	II 0		II 0	2 0	II 0	I 0		2 0	1 0					II	115
	Rhus chinensis	I 0	II 0		I 3		II 0				3 0	1 0	II 0	I +					R 0	I 0	I 0		III 11	I 0	II 9		II 0	II 3	III 4								2 4		0			I	52
25	*Lysimachia clethroides*	II 0	II 0		I 0		I 0							I 0					I 0	I 0	I 0		I 0	I +	I 0		I 0	R 0	III 0					I 0								I	32
	Zanthoxylum schinifolium	III 0	II 0		I 0		I 0				2 0	3 0	III 0	I 0					I 0	R 0	I 0			I 0	III 0	2 0		I 0	III 0					II 0						0		I	42
26	*Populus × tomentiglandulosa*				II 10	I +	I 18							II 0					I 10				I +		I +	3 18			I 0		V 53	4 44				1 0				0		I	32
27	*Castanea crenata*	I 0			I 5	III 7	I +	2 +	I 8		1 +			II 4			1 +		III 5	III 4	II +	II +			I 0		IV 5	I 2		III 4	II 3	1 0	V 51	II 4		1 0						II	92
	Viburnum erosum		I 0		II 0	II 0	I 0	2 0	I 0		1 0	1 0	I 0	I 0			2 4	0	I 0	I 0	II 0						II 0	I 0		I 0		1 0	III 2	I 0								I	45
28	*Alnus hirsuta*				III +	II +	II 5		V 12				I 0	I 0	I +		2 +		IV +	II +	III 14	II +	III 6	II 0		3 12	III 4	II 6	III 3	I +	II 3	1 +		V 35		2 +						II	117
	Celastrus orbiculatus				I 0	I 0						1 0	I 0				1 0	0	I 0	II 0	II 0				I 0		II 0	I 2					I 0	III 0		1 0						I	43
	Athyrium niponicum	I 0			I 0		I 0	1 +				2 0	I 0							R 0							I +						I +	II +								R	13
29	*Larix leptolepis*	I +			I +		I 18												R +	R +			I +					R +							3 79	3 46						R	14
30	*Pinus koraiensis*		I +			I 0		1 +											I 4	R 0				III 5	II 5		I 0					1 63			1 18	1 0	4 63			8		I	24
31	*Pinus thunbergii*							1 +											R 6	R +	I 0								I 0							1 0		2 88				R	7
32	*Ailanthus altissima*																			R 18				I +															38			R	3
33	*Abies holophylla*																																							63		R	1
34	*Picea abies*																																								63	R	1

Note: companions omitted(140 species).

ing two subgroups and *Athyrium yokoscense* - *C. crenata* group. *Populus tomentiglandulosa*(POTO) plantation is distinguished from other communities by the presence and dominance of the differential species group 2, 18 and 26. This is further subdivided into two lower units of *Athyrium yokoscense* - *J. rigida* group and typical group. *Larix leptolepis*(LALE) plantation is distinguished from other communities by the presence and dominance of the differential species group 1, 6 and 29. This is further subdivided into two lower units of *S. alnifolia* - *Q. mongolica* group and typical group. *Castanea crenata*(CACR) plantation, *Alnus hirsuta* (ALHI) plantation, *Pinus koraiensis*(PIKO) plantation, *Pinus thunbergii*(PITH) plantation, *Ailanthus altissima*(AIAL) plantation, and *Abies holophylla*(ABHO) plantation are distinguished from other communities by the presence and dominance of the differential species group 27,28,30,31,32, and 33 respectively.

Constancy classes by vegetation units

According to the constancy diagram of Fig. 1, the lower classes (≤ II) have 97.4% in the forest plants occurring to this area, the mid-classes (III) 0.5%, and the higher classes (≥ IV) have only 2.1%. Its shows that species of the higher constancy classes can readily replace one another in different stands of the same communities and dominate broadly. However, plant species, having the lower classes are distributed sparsely in the disturbed sites or the extremely limited sites.

A detailed vegetation mapping and its landscape ecological review

As a sample of the basic map for the ecological conservation and management of vegetation landscape of urban forests, a detailed vegetation map at a scale of 1: 5,000 was made in the study area, based on floristic composition and structure of the vegetation units, by the phytosociological methods (Fig. 2). In drawing units, community level showed by the borderline and color, the group level by the patterns, and the subgroup level, which are the lowest units, by serial numbers.

Total area for detailed mapping was 443.3 ha, of which artificially induced vegetation accounted for 316.8(71.5%), the largest portion, naturally regenerated vegetation for 101.2 ha (22.8%), and others such as bare ground, arable land, graveyard, incised land, etc, for 25.3 ha (5.7%). The ratio of natural forest element at 31.9% showed that this area was mainly comprised of artificially induced vegetation such as *Robinia pseudo-acacia* plantation and *Pinus rigida* plantation. This is very lower than that of the forestland in the other urban area (mostly 50-70%). The distribution area by vegetation units was highest at *R. pseudoacacia* plantation (209.3 ha), lowest at *Ailanthus altissima* community (0.2ha) (Fig. 3). The ratio of natural forest element showed 31.9%.

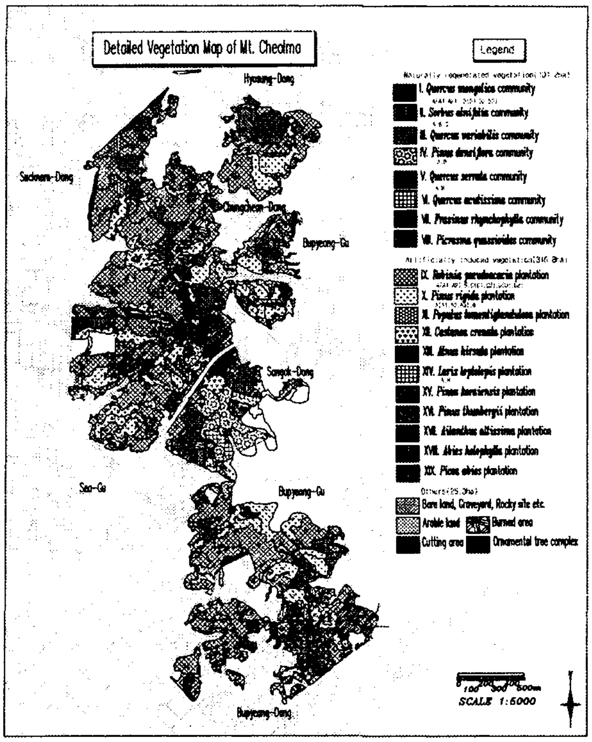

Fig. 2. Detailed vegetation map of Mt. Cheolma in Incheon city, Korea.

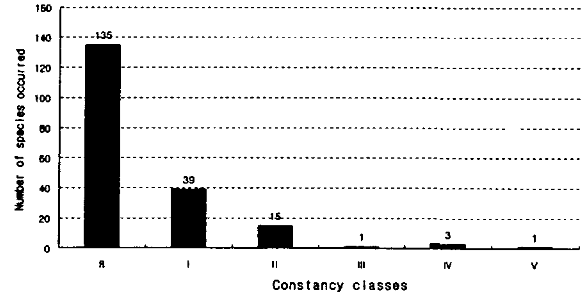

Fig. 1. Constancy classes diagram of component species.

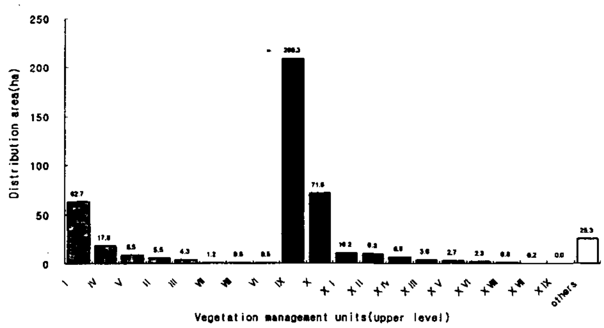

Fig. 3. Distribution area by forest vegetation management units in Mt. Cheolma(based on upper level, Roman letters refers to Table 1).

Table 2. The configuration of forest landscape elements identified from the vegetation map of Mt. Cheolma, Incheon city

landscape element types(LET)	Total area (ha)	Number of patches	Mean size of patches(ha)	Patch density (/100ha)	Species richness
LET of naturally regenerated vegetation(NRV)					
Quercus mongolica community	62.7(14.1)	30(10.2)	2.1	47.8	90
Sorbus alnifolia community	5.5(1.2)	11(3.8)	0.5	200.7	38
Quercus variabilis community	4.3(1.0)	2(0.7)	2.1	46.8	27
Pinus densiflora community	17.8(4.0)	3(1.0)	5.9	16.9	45
Quercus serrata community	8.5(1.9)	8(2.7)	1.1	94.6	47
Quercus acutissima community	0.5(0.1)	1(0.3)	0.5	197.1	7
Fraxinus rhynchophylla community	1.2(0.3)	2(0.7)	0.6	160.1	41
Picrasma quassioides community	0.8(0.2)	1(0.3)	0.8	132.6	24
Subtotal	**101.2(22.8)**	**58(19.8)**	**1.7**	**57.3**	
LET originated in forestry(IVF)					
Robinia pseudoacacia plantation	209.3(47.2)	57(19.5)	3.7	27.2	143
Pinus rigida plantation	71.6(16.1)	48(16.4)	1.5	67.1	90
Populus tomentiglandulosa plantation	10.2(2.3)	11(3.8)	0.9	108.2	53
Castanea crenata plantation	9.3(2.1)	12(4.1)	0.8	128.7	52
Alnus hirsuta plantation	3.6(0.8)	4(1.4)	0.9	111.2	55
Larix leptolepis plantation	6.9(1.6)	8(2.7)	0.9	115.9	43
Pinus koraiensis plantation	2.7(0.6)	6(2.0)	0.5	221.0	23
Pinus thunbergii plantation	2.3(0.5)	3(1.0)	0.8	128.2	7
Ailanthus altissima plantation	0.2(0.0)	1(0.3)	0.2	652.4	10
Abies holophylla plantation	0.8(0.2)	1(0.3)	0.8	130.2	13
Picea abies plantation	0.0(0.0)	1(0.3)	0.0	4276.4	3
Subtotal	**316.8(71.5)**	**152(51.9)**	**2.1**	**48.0**	
LET originated in agriculture(IVA)	**6.2(1.4)**	**15(5.1)**	**0.4**	**242.8**	
Others					
Burned area	4.6(1.0)	2(0.7)	2.3	43.6	
Bare ground, graveyard, rocky sites etc.	7.4(1.7)	56(19.1)	0.1	751.7	
Incised land	7.1(1.6)	10(3.4)	0.7	141.7	
Subtotal	**19.1(4.3)**	**68(23.2)**	**0.3**	**356.2**	
Total	**443.3(100.0)**	**293.0(100.0)**	**1.5**	**66.1**	

The other secondary forest and plantation tend to distribute as small patches in and around matrix of *R. pseudoacacia* plantation and *P. rigida* plantation. Numerous *Quercus* species consisting potential natural vegetation is established in substratum of plantation existing as a matrix. From these results, we could predict change of forest landscape with the progression of vegetation succession. *Q. serrata* community, *Q. acutissima* community, *Fraxinus rhynchophylla* community, and *Picrasma quassioides* community, which are considered as a remnant patches, exists in the valley and the lower part of slope. Other elements including arable land, road, graveyard, incised land, etc., are distributed throughout the study area but are mostly concentrated on the lower parts of slope, valley, and roadsides. On the other hand, the diverted area as residential area, semi-industrial area, and military area etc, is mostly restricted on the lower parts of the study area.

The number, size and density of patches

Using the vegetation map, we summarized patch type, area, number and density. We also calculated landscape diversity index (Shannon and Weaver 1962). The landscape element types (LET) identified from the detailed vegetation map are summarized in Table 2. LET of Mt. Cheolma are identified as naturally regenerated vegetation (NRV), introduced vegetation for forestry (IVF), introduced vegetation for agriculture (IVA), and others including burned area, treeless area, bare ground, incised area, graveyard, rocky sites and so on. Three landscape element types, which dominate in the area, are *R. pseudoacacia* plantation and *P. rigida* plantation, and *Q. mongolica* community. *R. pseudoacacia* plantation is the dominant landscape element type and *P. rigida* plantation the second dominant type. These types were introduced in the twenty to thirty years ago for erosion control and now have been declined by its ecological age and natural succession. NRV was composed of eight landscape element types and IVF composed of eleven types. The number and size of patches reflect the intensity of disturbances caused by both nature and man in the human-influenced landscape, and hence they become indices reflecting the intensity of disturbance (Turner 1989; Raedeke and Raedeke 1995). The vascular plant species richness of the landscape element types in Mt. Cheolma was found to be positively related to their size and disturbance. Percentage occupied by the IVF patches among the total number of patches (71.5%) was a much more than that of the NRV elements (22.8%). The number of *R. pseudo-acacia* patches, *Pinus rigida* patches and *Quercus mongolica* patches was particularly numerous and occupied 19.5%, 16.4% and 10.2% of total number of patches, respectively. Causal factors of patch differentiation, viz. landscape fragmentation can be recognized by comparing the number of patches per unit area of each landscape element (Lee *et al.* 1998a). When the number of patches per unit area (/100ha) between NRV and IVF is compared, the mean number of patches of the former was more than that of the latter (57.3 vs. 48.0). NRV patches are emerged patches or remnant patches with the progression of succession and artificial protection in the study area. From those results, we could know that causal factor of forest landscape fragmentation would be related to the development of succession process and remnant patches. Such results showed similar one to that obtained from the other.

Urban areas of Korea, in which excessive artificial interference were causal factors of landscape fragmentation (Lee *et al.* 1998). In the mean size of patches per landscape element type, IVF types were a little larger than that of NRV types (2.1ha vs. 1.7ha). Especially, *P. densiflora* community protected and sustained by the military affairs and topographic factors, which showed the greatest size among all of the landscape element types. That is, the size of patches in the lower part and valley part of the study area near the urbanized area was showed the smaller one than those above the mid-slope. From this result, we could know that differentiation of patches in community level in isolated areas like the study area was mostly dependent on artificial interferences. Most patches in the sub-communities (group level) seem to be originated from the natural succession after the artificial disturbances. In fact, that the number of patches in group level in distant sites from the urbanized area, in which artificial interference was mild, was more than that in near sites from the urbanized area under severe artificial interference prove such estimation (Cho *et al.* 1999).

For this area, *R. pseudoacacia* plantation is the dominated ecosystem type, with large patches forming the landscape matrix, but patch density (PD) is the lowest next to *P. densiflora* community among forest patch elements. The very abundant small patches are dispersed across urbanized area. Because the dominant *R. pseudoacacia* matrix has been replaced with a variety of second-growth forest types. Landscape diversity for the study area showed 0.87 and IVF elements higher than that of NRV elements (1.45 vs. 1.68). From above results, we could estimate that patches in community level recognized as homogeneous pattern by aerial photograph were mainly introduced elements and those in sub-community level were mainly regenerated ones originated from natural process of succession. Therefore, even though a forest was recognized as homogenous pattern by aerial photograph, its internal structure is changed to heterogeneous one by artificial interference or natural recovery after disturbances of diverse types (Küchler and Zonneveld 1988, Nakagoshi *et al.* 1992, Forman 1995).

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