National Database, Evaluation and Assessment of Plant species based on the phytosociological Information

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Abstract : The multicriterion matrix technique (MM-technique) was proposed for a method of monitoring and assessment about vegetation naturalness. Four criteria and 10 subcriteria were selected and two evaluation indices such as VN-value and VN-class were used. The criteria were characterized by syntaxonomical informations of hemeroby concept and potential natural vegetation, hierarchical system between criteria, and ordinal scale of VN-values. VN-values were classified into 11 ordinal levels and condensed to five VN-classes for facilitating practical use. A vegetation map of naturalness described by combination of two indices was proposed as an alternative resolution of the DGN map. We also discuss the organization of the map content which is a matter of grid size (unit-area). In the case study, a grid size proper to show a full account of real information of actual vegetation is less 250-grid (250 x 250 m^2) in a medium size of city area containing relatively fragmented ecosystems. In conclusion, it was recognized that this new assessment technique was useful and vegetation assessment was accomplished with the smaller grid size in Korea.

Keywords : Ecological assessment, Hemeroby classification, Naturalness value, Nature conservation, Vegetation class.

Abbreviations : DGN = Degree of Green Naturality; EIA = Environmental Impact Assessment; MM-technique = Multicriterion Matrix technique; MVN = Map of Vegetation Naturalness; VN-class = Vegetation Naturalness class; VN-value = Vegetation Naturalness value.

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Introduction

In an ecological assessment on the regional vegetation, qualitative evaluation must be primarily considered due to its reflection on the ecological values of individual plant species or associations of plant species having a similar ecological amplitude (Spellerberg, 1992). A qualitative method using a objective evaluation technique may be more efficient than a quantitative method in the ecosystem assessment, because indeed it is impossible to acquire precisely quantitative information.

On the other hand, assessment of ecosystem has been applied usefully to the environmental impact assessment of the region and supported to provide ecological guidelines to conserve a natural ecosystem. A simple assessment technique on the vegetation naturalness has been suggested for protecting important plant communities (Ohba, 1980). Recently, a qualitative and quantitative assessment reflecting the human impacts to the naturalness assessment of the region for the establishment of natural managing politics of country in the world (Koch et al., 1997; Koch & Kirchmeir, 1997).

A phytocoenosis is a group of plant species living together in a habitat comprising homogeneous biotic and abiotic environment. Syntaxonomical data about a phytocoenosis provide a direct and indirect information about its habitat (Becking, 1957). A certain particular habitat may contain a critical keystone phytocoenosis occupying only a small area of the habitat (Primack, 1995). The mountain peat bog in South Korea is extremely rare and occupies a small area, yet is crucial to many bog species and communities (Kim, 1996). One of the most common features of habitat assessment in Korea is the degree of green naturality (after DGN) in a given area (Chung et al. 1984). However, the DGN is a wholly incomplete measure regardless of vulnerability of plant communities and species (Kim 1993, 1994a, 1994b). A specialized assessment technique should be developed, particularly on the conservation of keystone phytocoenosis in South Korea where comprises high population density and intensive land use.

From these point of view, present study involves a development and practical application of the vegetation assessment method useful in Korea and discussion about the existing vegetation assessment method used under the institution (e.g. Environmental Administration, 1995).

Material and Methods

1. Establishment of estimation system for vegetation naturalness

The Multicriterion Matrix Technique (after MM-technique) was invented for vegetation naturalness assessment about plant community (Table 1). Four assessment criteria were set up in it. They are (1) origin of vegetation development, (2) geographical distribution, (3) important species' existence in situ or not, and (4) life history of plant community. Each criterion is divided into the two or three sub-criteria by characters. Allocation of score classes to ordinal values is based on the form of characters in terms of hemeroby classification and potential natural vegetation concept.

Table 1. Multicriterion evaluation matrix based on ordinal value of vegetation g naturalness.

Development origin					anthropogenic (Ao)			wilderness (Wo)		
Geographical distribution					national (Nd)	provincial (Pd)	local (Ld)	national (Nd)	provincial (Pd)	local (Ld)
					0	1	2	3	4	5
Monitored Individual species	− (Es)	Life history of plant community	s (St)	0	[0]	[1]	[2]	[3]	[4]	[5]
			m (Mt)	1	[1]	[2]	[3]	[4]	[5]	[6]
			l (Lt)	2	[2]	[3]	[4]	[5]	[6]	[7]
	+ (Is)		s (St)	3	[3]	[4]	[5]	[6]	[7]	[8]
			m (Mt)	4	[4]	[5]	[6]	[7]	[8]	[9]
			l (Lt)	5	[5]	[6]	[7]	[8]	[9]	[10]

Abbreviated words in a parenthesis : Ao - Anthropogenic origin, Es - Ex-situ, Is - In-situ, Ld - Local distribution, Lt - Long-term history, Mt - Mid-term history, Nd - National distribution, Pd - Provincial distribution, St - Short-term history, Wo - Wilderness origin.

(1) Origin of vegetation development

Two different origins on the formation and development of plant community were recognized in terms of phytosociology. Some plant communities are maintained by the artificial interference or disturbance. Ruderal plant communities such as *Plantago asiatica* community and Bryo-Saginetum japonicae are representative. Most mantle communities of the Rosetea multiflorae *sensu lato* are representative to anthropogenic plant community as well. Others are wilderness type of plant communities developing under the natural condition excluding anthropogenic interferences. These allocate hierarchically the highest order with regard to the ultimate goal of conservation

(2) Geographical distribution

In Korea, six syngeographical zones have been recognized: alpine and subalpine, cool-temperate northern · altimontane, cool-temperate central · montane, cool-temperate southern · montane, and warm-temperate (Kim, 1994c, 1996).

Geographical distribution pattern of plant community is defined one of three subcriteria such as national, provincial, and local according to its horizontal and altitudinal distribution pattern in the syntaxonomical zone. Basically, the wide distribution throughout the nation is termed as a national distribution. Plant community occurring beyond two syntaxonomical zones is defined as a national distribution as well. Concentrative distribution within a one particular syngeographical zone and a geographical region (incl. climate zone) is considered as a provincial distribution. While, endemic plant communities to specific habitats are the best example of local distribution. They are limited at the unique ecological habitats such as a limestone and serpentine areas, mountain peat bogs, and a few localities with small population size in Korea.

(3) Monitored individual species

Plant community containing some important species should be monitored for ecological conservation, and also evaluated as a higher conservation value. Measurement of important species is accomplished by a separate matrix table composed of four criteria such as geographical distribution, nativeness and ethnobotanics, specificity of habitat, and reproduction strategy of the individual plant species (Table 2).

Table 2. Multicriterion evaluation matrix of plant species.

Geographical distribution					national		provincial		local	
Endemism					–	+	–	+	–	+
(*incl.* endemic, subendemic & ethnobotanic)					0	1	2	3	4	5
Habitat specificity	–	Ecological strategy	clonal & annual	0	**[0]**	**[1]**	**[2]**	**[3]**	**[4]**	**[5]**
	–		infiltration	2	**[2]**	**[3]**	**[4]**	**[5]**	**[6]**	**[7]**
	+		clonal & annual	4	**[4]**	**[5]**	**[6]**	**[7]**	**[8]**	**[9]**
	+		infiltration	6	**[6]**	**[7]**	**[8]**	**[9]**	**[10]**	**[11]**

An estimation technique of important species is basically identical to MM-technique for plant community, yet slightly different in allocation of criteria. Geographical distribution of plant species is divided into national, provincial, and local distribution patterns on the individual species level. This criterion of species distribution has to be allocated at top hierarchy in the matrix table due to its functional and structural role in ecosystem and species diversity in a given area. Endemic and ethnobotanic plant species were weighted as an important species with monitoring necessity. In general, habitat specificity of plant species means the ecologically most suitable environmental site to the particular species showing narrower ecological amplitude. In present study, habitat specificity involves the sensitiveness to habitat's transformation caused by human impact.

Fourth criterion for selecting a weighted plant species is based on reproductive strategies to occupy spatial area such as (1) clonal or annual plant species or (2) others including seed dispersion strategy mainly. The former plant species are more tolerative and competitive to disturbed sites than the later.

From this multicriterion evaluation matrix of plant species, we can obtain 12 kinds of conservation values, [0] to [11]. For practical understanding, these conservation values were discriminated as five conservation classes, [I] to [V], and then plant species showing a more than conservation value [5] was considered as one of threatened species *i.e.* a weighted species being worthy of monitoring sufficiently. Most plant species showing a habitat specificity and local distribution patterns belong to the conservation class [V] (Table 3). In present study, we used a base book entitled as standard illustrations of Korean plants (Lee, 1997) for the plant name and ecological information used in the determination of monitored individual species of existing plants resources of Korea (Kim 1997, in preparing).

Table 3. Selection of weighted species by species evaluation matrix of table 2.

Conservation class			Conservation value	Conservation intensity
I	not monitoring	common species	[0], [1], [2]	lower
II	general monitoring		[3], [4]	↑
III	principal monitoring	weighted species	[5], [6]	↑ ↓
IV	critical monitoring		[7], [8]	↓
V	absolute monitoring		[9], [10], [11]	higher

(4) Life history of plant community

The fourth criterion of vegetation naturalness is a time-length on the development of plant community. We divided into three subcriteria such as short-term of 1-5 years, mid-term of 6-25 years, and long-term of above 26 years, with regard to syndynamics of the Korean vegetation under the continental monsoon climate belonging to the temperate forest region. In general, the ruderal plant community is short-term, the mantle plant community is mid-term, and a forest community with multi-strata or high moor vegetation is long-term in Korea. The late-successional vegetation types and perpetual plant communities which take relatively long time to recover after destruction may get higher VN-value as well.

2. Characteristics of MM-technique

Vegetation naturalness value (after VN-value) is classified into the eleven, [0] - [10] from the assessment matrix of plant community, and then divided to five vegetation naturalness classes (after VN-class), [I], [II], [III], [IV], [V], for the practical application and use in the environmental impact assessments (after EIAs) (Table 4). Each VN-class is characterized by a combination of vegetation assessment criteria. VN-class [I] and [V] represent anthropogenic vegetation and natural vegetation, respectively, which show a fairly opposite qualitative characteristics on the vegetation naturalness. The plant community involving a anthropogenic development origin and only general species may be assessed as VN-class [I], while the vegetation

Table 4. Vegetation classes and criteria combination with regard to vegetation conservation.

VN-class	VN-value	Criteria combination* (frequencies)	Ecologically needed protection activation	Vegetation properties
[I]	[0]	Ao-Nd-Es-St (1)	very weak	**Anthropogenic and artificial vegetation** ↑
	[1]	Ao-Pd-Es-St Ao-Nd-Es-Mt (2)		
	[2]	Ao-Ld-Es-St Ao-Pd-Es-Mt Ao-Nd-Es-Lt (3)		
[II]	[3]	Ao-Ld-Es-Mt Ao-Pd-Es-Lt Ao-Nd-Is-St Wo-Nd-Es-St (4)	weak and partly selective	
	[4]	Ao-Ld-Es-Lt Ao-Pd-Is-St Ao-Nd-Is-Mt Wo-Pd-Es-St Wo-Nd-Es-Mt (5)		
[III]	[5]	Ao-Ld-Is-St Ao-Pd-Is-Mt Ao-Nd-Is-Lt Wo-Ld-Es-St Wo-Pd-Es-Mt Wo-Nd-Es-Lt (6)	selectively obligatory	
[IV]	[6]	Ao-Ld-Is-Mt Ao-Pd-Is-Lt Wo-Ld-Es-Mt Wo-Pd-Es-Lt Wo-Nd-Is-St (5)	selectively strict	
	[7]	Ao-Ld-Is-Lt Wo-Ld-Es-Lt Wo-Pd-Is-St Wo-Nd-Is-Mt (4)		
[V]	[8]	Wo-Ld-Is-St Wo-Pd-Is-Mt Wo-Nd-Is-Lt (3)	very strict	
	[9]	Wo-Ld-Is-Mt Wo-Pd-Is-Lt (2)		
	[10]	Wo-Ld-Is-Lt (1)		↓ **Natural vegetation**

* Abbreviated words in the criteria combination coincide with those in Table 1.

being a wilderness community and containing some individual weighted species is assessed as VN-class [V].

On the other hand, qualitative assessment and conservation action plan for the plant community of VN-classes [II], [III], [IV] can be selectively determined according to combination of subcriteria belonging to the larger VN-values. For example, among the nine kinds of criteria combination in the VN-class [IV], plant community of the VN-value [7] must be more strictly protected than VN-value [6].

3. A case study for MM-technique

As a case study for testing the proposed MM-technique, we estimated a vegetation naturalness on two regions such as Ulreung-do and Sudokwon landfills in which the vegetation has been affected by relatively sound and intensive human interference, respectively (Table 5).

Table 5. Data for a case study.

	Ulreung-do (Tok-do)	Sudokwon landfills
Location	37° 30′ N, 130° 50′ E (37° 14′ N, 131° 52′ E)	37° 30′ N, 126° 38′ E
Area	73 km^2 (0.18 km^2)	81 km^2
No. of relevés	117	150
No. of plant communities	28	41
Floras	707 spp. (Lee & Yang 1981)	536 spp. (Kim *et al.* 1993)
Ecosystem	moderately altered areas and partly natural areas	severely interfered areas and partly urban areas
Sources	Kim *et al.* 1996	Kim *et al.* 1993

Qualitative comparison between two regions was performed by a vegetation index (N/A; N: total number of plant community *i.e.* vegetation richness, A: area (km^2) of the considered region), vegetation diversity analysis by a Shannon-Weiner index of vegetation naturalness ($D=-\Sigma P_i \cdot (\log_e P_i)$, $P_i = n_i/N$; n_i: number of plant community belonging to VN-class $_i$), and spectrum of hallow curve, for preliminary understanding. Total information about natural status of a given area can be exhibited on the hallow curve showing a VN-value on *x*-axis and a number of plant communities belonging to each VN-value on *y*-axis. In general, much urbanized and/or highly disturbed regions will show a typical hallow curve biased to one side, because of a large number of plant communities with smaller VN-value or domination of specific plant communities.

4. Vegetation map of naturalness using MM-technique

A resolution map was produced from the actual vegetation map for practical understanding on vegetation naturalness in a exampled area of Eiwang city. The actual vegetation map for Eiwang city was prepared as a detailed scale of 1:25,000 composed of 14 vegetation legends (land cover types) (Table 6). In order to determine the patchiness of vegetation cover types and the optimal grid size representing the nearly real information about land cover patterns, we considered a polygon-size structure of legends dependant on different grid sizes such as 250-grid (250m×250m), 500-grid (500m×500m), 750-grid (750m×750m), 1000-grid (1000m×1000m), and 1250-grid (1250m×1250m). The polygon-size structure was quantified by the mean area of a one polygon about each legend and the percent of polygons in which each legend with a given grid size occurred. The optimal grid size can be determined through logistic decline curve based on polygon number and grid size.

Table. 6. Land cover types summarized from actual vegetation map of Eiwang city.

Types	Vegetation type	Characteristic species	Area in Eiwang		VN-class
			Km^2	%	
01	Nearly natural mountain oak forests	*Quercus serrata, Q. mongolica*	3.42	6.4	[V]
02	Zelkova valley forests	*Zelkova serrata, Acer mono, Styrax japonica*	0.27	0.5	[V]
03	Secondary oak forests	*Quercus variabilis, Quercus aliena*	5.13	9.6	[III]
04	Secondary pine forests	*Pinus densiflora, Juniperus rigida*	0.32	0.6	[II]
05	Afforestation vegetation	*Pinus rigida, P. koraiensis, Robinia pseudoacaccia*	1.82	3.4	[I]
06	Mixed inferior forests	*Robinia pseudoacaccia, Pinus rigida, P. densiflora*	19.94	37.3	[II]
07	Segetal vegetation in wet (peddy) field	*Oryza sativa, Monochoria vaginalis* var. *plantaginea, Sagittaria aginashi*	3.74	7.0	[I]
08	Segetal vegetation in dry field	*Portulaca oleracea, Centipeda minima*	7.33	13.7	[I]
09	Secondary weeds and ruderal vegetation	*Pulsatilla koreana, Zoysia japonica, Ajuga multiflora, Crotalaria sessiliflora*	0.96	1.8	[I]
10	Graminoid wetlands	*Typha angustata, Scirpus fluviatilis*	0.05	0.1	[II]
11	Reclaimed areas	*Eragrostis multicaulis*	0.8	1.5	[I]
12	Rural settlement	*Chenopodium album* var. *centrorubrum*	1.71	3.2	[I]
13	Urban settlement	*Bryum argenteum, Sagina japonica*	6.74	12.6	[I]
14	Open water	*Trapa japonica*	1.23	2.3	[I]

The logistic decline curve indicates extensive early decreasing raps rate of polygon numbers by increasing of grid size. This is true, for instance, of Korea's cities containing many small areas of vegetation types which have been intensively fragmented by human activities. The general form of the equation for the logistic decline curve is:

$$Y=k/(n+m \cdot s \cdot e^{rt}),$$

where Y is the polygon number in a given grid size t. Four parameters k, n, m, and r were estimated by [SAS] package (SAS institute Inc., 1991) in consideration of actual data Y and t. Parameter r is a measure of growth rate of grid size. The minimal grid size was assumed to be adequate when a given raps rate of grid size produces less than the same raps rate ($r=1$) in the number of polygon. This method is basically identical with determination of minimal area (*e.g.* Kim *et al.*, 1995).

Result

1. Vegetation naturalness on the disturbed and undisturbed areas

The vegetation richness of Sudokwon landfills region showed higher than Ulreung-do region, but lower in the vegetation diversity (Table 7). Such a higher richness (41) and lower diversity (0.51) of Sudokwon landfills are typical on the disturbed region. In fact, the Sudokwon landfills is predominantly covered by ruderal plant communities showing a specific VN-value and various plant communities derived from diverse human interferences.

Table 7. Comparison of vegetation naturalness between two exampled areas.

Areas	Vegetation			VN-class				
	index	diversity	richness	[I]	[II]	[III]	[IV]	[V]
Ulreung-do · Tok-do	0.38	1.71	28 (100.0%)	13 (46.4)	3 (10.7)	2 (7.1)	2 (7.1)	8 (28.7)
Sudokwon landfills	0.51	0.96	41 (100.0%)	33 (80.5)	8 (19.5)	0 (0.0)	0 (0.0)	0 (0.0)

Plant communities occurring in Ulreung-do region show a even distribution pattern throughout various VN-values, but in the Sudokwon landfills a 80.5% of plant communities is VN-class [I] showing biased distribution pattern (Fig. 1). The Sudokwon landfill is a famous reclaimed area located near the metropolitan Seoul in Korea. On the other hand, Ulreung-do region is a remote islands with inaccessible topography. Therefore, vegetation quality between two regions is quite different. Dominant vegetation types in the Sudokwon landfill are anthropogenic plant communities, while natural *Fagus* forests and costal cliff rocky scrub vegetation are primary vegetation types in Ulreung-do and Tok-do. In conclusion, it is recognized that vegetation diversity analysis using a VN-class or a VN-value is one of propertools to describe a regional naturalness and vegetation quality.

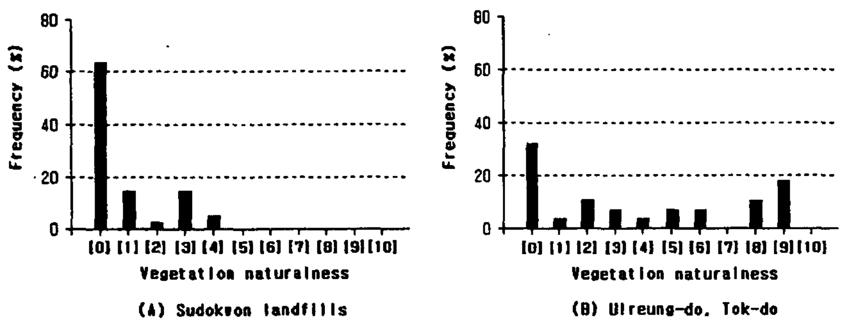

Fig. 1. Distribution of vegetation naturalness in the Sudokwon landfills and Ulreung-do Islands.

2. Optimal grid size and vegetation patchiness

The number of polygons was exponentially decreased according to the increase of grid sizes (Table 8). The equation between the number of polygons and grid sizes were determined $Y=2.68/(-0.00462+0.01e^{0.00322t})$ and the estimated minimal grid size was about 0.096km^2 (310.559 x 310.559 m^2) in Eiwang city. Therefore, we can recognize that the optimal grid size among the tested grid sizes in Eiwang city is a 250-grid size which is less than about 310-grid size estimated.

Table 8. Composition of vegetation cover types according to grid sizes.

Type	Area (km^2)	Grid size (km^2)																	
		125x125			250x250			500x500			750x750			1000x1000			1250x1250		
		A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
01	3.42	3	0.323	1.14	3	0.75	1.14	3	1.961	1.14	3	9.375	1.14	3	16.667	1.14	2	20	1.71
02	0.27	19	2.045	0.014	19	4.75	0.057	5	3.268	0.054	0	0	0	0	0	0	0	0	0
03	5.13	87	9.365	0.059	56	14	0.092	18	11.765	0.285	3	9.375	1.71	2	11.111	2.565	1	10	5.13
04	0.32	25	2.691	0.013	10	2.5	0.032	1	0.654	0.32	0	0	0	0	0	0	0	0	0
05	1.82	65	6.997	0.028	36	9	0.051	13	8.497	0.14	1	3.125	1.82	0	0	0	0	0	0
06	19.94	103	11.087	0.194	72	18	0.277	40	26.143	0.499	13	40.625	1.534	8	44.443	2.493	4	40	4.985
07	3.74	82	8.827	0.046	58	14.5	0.064	24	15.686	0.156	2	6.25	1.87	1	5.556	3.74	0	0	0
08	7.33	188	20.238	0.039	93	23.25	0.079	34	22.222	0.216	5	15.625	1.466	0	0	0	0	0	0
09	0.96	83	8.934	0.012	13	3.25	0.074	3	1.961	0.32	0	0	0	0	0	0	0	0	0
10	0.05	5	0.538	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0.80	36	3.875	0.022	13	3.25	0.062	2	1.307	0.4	0	0	0	0	0	0	0	0	0
12	1.71	221	23.789	0.008	17	4.25	0.101	2	1.307	0.855	0	0	0	0	0	0	0	0	0
13	6.74	10	1.076	0.674	8	2	0.843	6	3.922	1.123	3	9.375	2.247	3	16.667	2.247	3	30	2.247
14	1.23	2	0.215	0.615	2	0.5	0.615	2	1.307	0.615	2	6.25	0.615	1	5.556	1.23	0	0	0
	53.36	929			400			153			32			18			10		

A: Polygon No.; B: Percent of polygon; C: Mean area of polygon. Vegetation types are identical to those of Table 6.

On the other hand, the legibility of a vegetation patchiness depend inter alia on the dimensions of the smallest vegetation cover areas to be shown. 125-grid map provided really accurate information on the present vegetation which is shown the relatively high patchiness of Eiwang city, 250-grid map presented similar pattern as well (Fig. 2). This means that a minimal grid size is the fully informative and important component to show nearly exact vegetation extent in a given area.

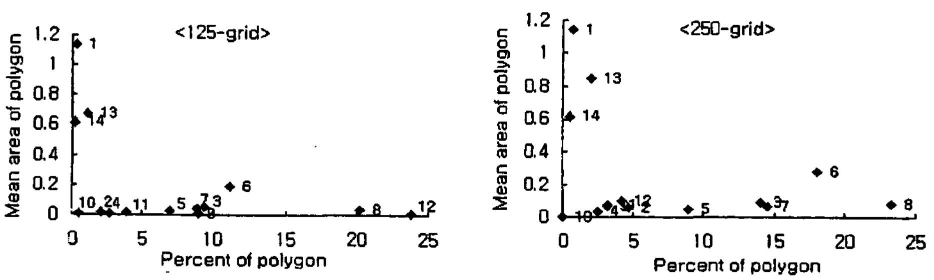

Fig. 2. Vegetation patchiness in Eiwang city. Numers indicate legends of vegetation cover with small size (mean polygon area) shows the high polygon frequency

Discussion

1. Vegetation assessment in the EIAs and MM-technique

In Korea, present environmental impact assessment includes several measures for ecosystem assessment such as floral and faunal list, actual vegetation map, land biomass, degree of green naturality (DGN), and richness of naturalized plants in a given area. In particular, DGN has been used as one of the most important measure between issues of regional development and ecosystem conservation (Chung *et al.*, 1984; Environmental Adminstration, 1989, 1991, 1995). But the DGN has serious problems on the achievement of such final goals of the ecosystem assessment (*e.g.* Oh & Lee, 1994).

The DGN is originally a hemeroby classification of plant communities obtained from the phytosociological study (Miyawaki & Fujiwara, 1975). In Korea, the national DGN map was completed in 1990, but any practical use for national ecosystem management has never been found owing to the false information different from actual vegetation status. This is caused by several reasons: (1) application of same legend to the syngeographically and syntaxonomically different regions, (2) canopy age and physiognomy instead of community structure, (3) limitation of numerical treatment of DGN nominal scale for database, and (4) indeterminable information on the biodiversity conservation involving threatened and rare species (Kim, 1993, 1994a, 1994b). In addition, it is impossible to estimate quantitative biomass value of ratio scale from qualitative DGN value of nominal scale, although the land biomass was estimated by combination of Miami model and DGN value (Lieth 1972; E. Box personal communication, 1997). Of course Miami model is more profitable to global level than local level.

On the other hand, there is a judgement of urbanization by richness of naturalized plant (a number of naturalized plant species and total number of plant species calculated in a given area; Yim & Jeon, 1980). But this is also an improper tool for the vegetation assessment. In general, a few synanthrophic species tend to predominate over urban areas, while many kinds of species and a little coverage of individual species occur in natural areas. Thus, behavior of such naturalized plant in the interfered area is rather qualitative parameter for urbanization, and also there is disparity of scale attribute between quantitative ratio of naturalized plant and qualitative term of urbanization. In conclusion, it may be acknowledged that current measures such as DGN, vegetation biomass estimation and richness of naturalized plant are improper tools for the assessment of vegetation naturalness in a given area.

Environmental impact assessment of ecosystem should be done by an assessment techniques possible to estimate a exiting conservation biological or potential values supporting the function and structure of regional ecosystem. The multicriterion matrix of MM-technique is characterized by three properties such as (1) a logical system of combination of hemeroby and potential natural vegetation concept considering human interference to plant community, (2) hierarchical system between criterion's character set, and (3) ordinal scale about conservation value of plant community.

Development of assessment technique on the naturalness of plant community has been early examined in Japan where has progressed the vegetation science (Japanese Environment Administration, 1980). In particular, attribute of the assessment technique proposed by Ohba (1980) is similar to this MM-technique with regard to using syntaxonomical information. Plant community was assessed by adding point of ordinal scale based on each vegetation assessment criterion. But, big difference between both techniques is of logical process to order to obtain VN-value of which the MM-technique involves hierarchy system of assessment criteria with a real ordinal scale.

2. Map of vegetation naturalness and unit grid size

Mapping of vegetation assessment is a very important process for a practical application, in particular, essential for monitoring an important vegetation with higher VN-class. Especially in Korea with aggressive land-use and intensive human interference to the ecosystem, most natural vegetations of VN-class [V] and [IV] occur in a very small and restricted size of area (Kim *et al.*, 1997). The map of vegetation naturalness (after MVN) derived by combining VN-class and VN-value is more complementary and satisfactory than the map of DGN (Environment Administration, 1991), a forest physiognomy map (Forestry Research Institute, 1988), and an actual vegetation map (Environment Administration, 1989) in terms of conservation biological information and analytic technique (Table 9).

Table 9. Comparison of principle components for the assessment of vegetation naturalness.

Assessment components of criteria		VN-class (present study)	Degree of green naturality (EA, 1991)	Actual vegetation classification (EA, 1989)	Forest type classification (FRI, 1987)
species composition		++	+	+	+
hierarchical system		++	+	+	−
syngeography		++	−	−	−
vegetation restoration		++	+	−	+
plant	currently economical	+	−	−	++
resource	potential & ecological	++	+	−	−
physiognomy		+	+	++	++
naturalness scale		ordinal	nominal	none	none

Notes : ++ primarily consideration, + weakly consideration, − neglect
Abbreviations of sources: EA - Environment Administration, FRI - Forestry Research Institute.

The MVN can be drawn by mesh or by contour line in accordance with specific purpose, and then dominant VN-class in a unit area can be inscribed. The superscript of largest VN-value and subscript of smallest VN-value are written in right margin of VN-class. This inscription is helpful to understand the status of vegetation naturalness in a given unit area (Fig. 3).

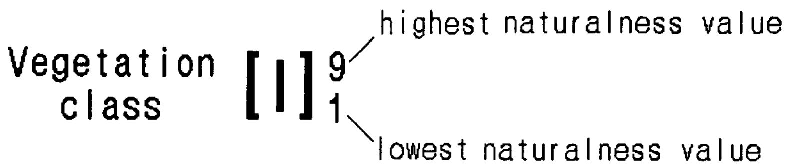

Fig. 3. Inscription of VN-class and VN-value in the map of vegetation naturalness.

Even if a unit area is assessed as the lower VN-class, the plant community of a large VN-value should be protected. Geographical locations about such plant communities larger than VN-class [III] should be pointed out on the MVN. In addition, a digital map of vegetation naturalness will bring about a establishment of long-term monitoring system of important vegetation resource in the given areas, particularly a mesh map is very effective to assess vegetation naturalness on the base map of actual vegetation map.

On the other hand, a unit area in a mesh method for the MVN must be selected adequately according to the object of environmental impact assessment of ecosystem, implementation plan and characteristics of development and land use, and feature of natural ecosystem's structure and function in those regions. Kim (1994b) noted conventionally that one of the most serious problems was the apparent poor compatibility of grid sizes in a area, however, works on the vegetation mapping and vegetation assessment have steadily appeared and minimal grid sizes have never been regarded in Korea.

From the present study, we suggest that a recommendable minimal grid size is followed in Table 10. Most vegetation assessment in the EIAs should be accomplished by smaller grid size of 250mx250m. In the management of vegetation resources of national level, and in the establishment of long-term monitoring system, these grid size of vegetation assessment should be applied more small scale and uniformed size according as a specialism of field-researcher of vegetation and extension of auto-managing function by computer (Küchler & Zonneveld, 1988).

Table 10. Recommendable grid sizes of vegetation assessment.

Purposes to be assessed	Area size (km^2) to be assessed	Grid size (m^2) of assessment scale
National or regional survey	> 50	1000 x 1000
Local development	4~50	250 x 250
Others	< 4	100 x 100
Area unmodified (e.g. protected areas)		100 x 100

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Appendix I - Vegetation naturalness spectrum of Ulreung-do · Tok-do and Sudokwon landfills.

Ulreung-do · Tok-do

Plant communities	Criteria combination	VN-value	VN-class
Sedo takesimense-Thymetum quinquecostatae	Wo-Ld-Is-Mt	[9]	[V]
Hydrangea petiolaris-Sorbus commixta community	Wo-Ld-Is-Mt	[9]	[V]
Artemisio-Loniceretum insularidis	Wo-Ld-Is-Mt	[9]	[V]
Sedum takesimense-Allium senescens community	Wo-Ld-Is-St	[8]	[V]
Wasabia koreana community	Wo-Ld-Is-St	[8]	[V]
Hepatico-Fagetum multiflorae	Wo-Pd-Is-Lt	[9]	[V]
Tsugo sieboldii-Pinetum parviflorae	Wo-Pd-Is-Lt	[9]	[V]
Pseudosasa-Persea thunbergii community	Wo-Pd-Is-Mt	[8]	[V]
Hedera rhombea-Zelkova serrata community	Wo-Pd-Es-Lt	[6]	[IV]
Alnus maximowiczii community	Ao-Ld-Is-Mt	[6]	[IV]
Reynoutria sachalinensis community	Ao-Ld-Is-St	[5]	[III]
Cryptomeria japonica community	Ao-Pd-Is-Mt	[5]	[III]
Sedum oryzifolium community	Wo-Nd-Es-St	[3]	[II]
Saxifraga stolonifera community	Wo-Nd-Es-St	[3]	[II]
Pinus thunbergii community	Ao-Nd-Is-Mt	[4]	[II]
Sedum takesimense community	Ao-Ld-Es-St	[2]	[I]
Solidago virgaaurea var. *gigantea-Foeniculum vulgare* community	Ao-Ld-Es-St	[2]	[I]
Pseudosasa japonica community	Ao-Pd-Es-Mt	[2]	[I]
Miscanthus sinensis var. *purpurascens* community	Ao-Nd-Es-Mt	[1]	[I]
Ipomoea purpurea-Calystegia soldanella community	Ao-Nd-Es-St	[0]	[I]
Dianthus superbus var. *longicalycinus* community	Ao-Nd-Es-St	[0]	[I]
Chenopodium album var. *centrorubrum* community	Ao-Nd-Es-St	[0]	[I]
Polygonum aviculare-Tetragonia tetragonoides community	Ao-Nd-Es-St	[0]	[I]
Achyranthes japonica community	Ao-Nd-Es-St	[0]	[I]
Lythrum salicaria community	Ao-Nd-Es-St	[0]	[I]
Portulaca oleracea-Fatoua villosa community	Ao-Nd-Es-St	[0]	[I]
Equisetum palustre-Erigeron canadensis community	Ao-Nd-Es-St	[0]	[I]
Polygonum aviculare-Plantago asiatica community	Ao-Nd-Es-St	[0]	[I]

Sudokwon landfills

Pinus thunbergii community	Wo-Nd-Es-Mt	[4]	[II]
Quercus serrata-acutissima community	Ao-Nd-Is-Mt	[4]	[II]
Suaeda japonica community	Wo-Nd-Es-St	[3]	[II]
Aster trifolium-Salicornia herbacea community	Wo-Nd-Es-St	[3]	[II]
Phragmites communis-Carex scabrifolia community	Wo-Nd-Es-St	[3]	[II]
Aster trifolium-Sonchus brachyotus community	Wo-Nd-Es-St	[3]	[II]
Aster trifolium-Phragmites communis community	Wo-Nd-Es-St	[3]	[II]
Sagittaria aginashi-Monochoria korsakowi community	Ao-Nd-Is-St	[3]	[II]
Persicaria perfoliata-Spiraea salicifolia community	Ao-Pd-Es-Mt	[2]	[I]
Robinia pseudoacacia-Rosa multiflora community	Ao-Nd-Es-Mt	[1]	[I]
Castanea crenata community	Ao-Nd-Es-Mt	[1]	[I]
Pinus rigida community	Ao-Nd-Es-Mt	[1]	[I]
Pinus densiflora community	Ao-Nd-Es-Mt	[1]	[I]
Persicaria perfoliata-Clerodendron trichotomum community	Ao-Nd-Es-Mt	[1]	[I]
Persicaria perfoliata-Rhus chinensis community	Ao-Nd-Es-Mt	[1]	[I]
Trifolium repens-Zoisia japonica community	Ao-Nd-Es-St	[0]	[I]
Pteridium-Miscanthus sinensis var. *purpurascens* community	Ao-Nd-Es-St	[0]	[I]
Pueraria thunbergiana community	Ao-Nd-Es-St	[0]	[I]
Pennisetum alopecuroides community	Ao-Nd-Es-St	[0]	[I]
Miscanthus sinensis var. *purpurascens-Spodiopogon sibiricus* community	Ao-Nd-Es-St	[0]	[I]
Ambrosia artemisiifolia var. *elatior-Xanthium strumarium* community	Ao-Nd-Es-St	[0]	[I]
Equisetum arvense-Chelidonium majus var. *asiaticum* community	Ao-Nd-Es-St	[0]	[I]
Arthraxon hispidus community	Ao-Nd-Es-St	[0]	[I]
Polygonum aviculare-Plantago asiatica community	Ao-Nd-Es-St	[0]	[I]
Kummerowia striata-Oenothera odorata community	Ao-Nd-Es-St	[0]	[I]
Medicago sativa-Ambrosia artemisiifolia var. *elatior* community	Ao-Nd-Es-St	[0]	[I]
Melandryum apricum community	Ao-Nd-Es-St	[0]	[I]
Stellaria aquatica-Humulus japonica community	Ao-Nd-Es-St	[0]	[I]
Bidens frondosa community	Ao-Nd-Es-St	[0]	[I]
Sesamum indicum community	Ao-Nd-Es-St	[0]	[I]
Erigeron annus-canadensis community	Ao-Nd-Es-St	[0]	[I]
Centipeda minima-Portulaca oleracea community	Ao-Nd-Es-St	[0]	[I]
Digitaria sanguinalis-Echinochloa crusgalli community	Ao-Nd-Es-St	[0]	[I]
Oryza sativa community	Ao-Nd-Es-St	[0]	[I]
Cardamine lyrata-Juncus effusus var. *decipiens* community	Ao-Nd-Es-St	[0]	[I]
Persicaria thunbergii-Typha angustata community	Ao-Nd-Es-St	[0]	[I]
Typha orientalis community	Ao-Nd-Es-St	[0]	[I]
Zizania latifolia community	Ao-Nd-Es-St	[0]	[I]
Ottelia alismoides-Potamogeton cristatus community	Ao-Nd-Es-St	[0]	[I]
Calamagrostis epigeios community	Ao-Nd-Es-St	[0]	[I]
Imperata cylindrica var. *koenigii* community	Ao-Nd-Es-St	[0]	[I]

Abbreviated words of criteria combination : Ao - Anthropogenic origin, Es - Ex-situ, Is - In-situ, Ld - Local distribution, Lt - Long-term history, Mt - Mid-term history, Nd - National distribution, Pd - Provincial distribution, St - Short-term history, Wo - Wilderness origin.