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Classification and Pattern Analysis of the Forest Vegetation in Daedunsan Provincial Park, Korea

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大芚山 道立公園 森林植生의 分類와 類型分析

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ABSTRACT

The forest vegetations of Daedunsan provincial park area in Korea were classified into eight communities of *Acer mono-Zelkova serrata, Lindera erythrocarpa-Cornus controversa, Carpinus tschonoskii, Quercus variabilis, Quercus serrata, Carpinus laxiflora, Rhododendron schlippenbachii-Quercus mongolica* and *Rhododendron mucronulatum-Pinus densiflora* by the Z-M method. By two dimensional analysis of temperature, moisture gradients, the eight communities were grouped into four vegetation types: cove forest dominated with *Zelkova serrata* and *Cornus controversa*, hornbeam forest with *Carpinus tschonoskii* and *Carpinus laxiflora*, oak forest with *Quercus variabilis, Quercus serrata* and *Quercus mongolica* and pine forest with *Pinus densiflora.*

The potential natural vegetation map of the area(scale, 1:25,000) composed of *Quercus mongolica, Carpinus laxiflora, Carpinus tschonoskii, Zelkova serrta* and *Pinus densiflora* community was made from the analysis of actual vegetation map by the phytosociological classification, environmental conditions and human interferences.

INTRODUCTION

Daedunsan provincial park area is largely covered with mongolian oak (*Quercus mongolica*) and hornbeam (*Carpinus*) forest while the disturbed area with pine (*Pinus*) and cork oak (*Quercus variabilis*) forest as a secondary forest. Hornbeam and mongolian oak forests were recognized as a distinct forest vegetation in cool-temperate zone of Korea, and *Carpinus tschonoskii* and *Quercus mongolica* as the character species in southern and middle part of cool-temperate deciduous broadleaved forest zone, respectively (Uyeki, 1933; Yim, 1977). However, their natural forests are found only in extremely restricted areas, such as national and provincial park areas. Therefore, the detection of actual vegetation in these areas seems to be significant for the recognition of potential natural vegetation or nature conservation.

There are two main peaks, Machŏndae (877.7 m) and Chŏndŭngsan (706.9 m) in Dae-dunsan area, provincial park of Chŏllabukdo (ca. 38.1 km², 36°03′45″N—36°07′50″N, 127°16′15″E—127°21′20″E). The mountains are largely characterized by steep slopes with rock ridges or stony loam of upper parts and gravelly loam of lower parts.

For a long time, most trees in the mountain had been repeatedly cut for charcoal, house building or heating. The undergrowth of the forest has been grazed by domestic animals, and has been subjected to collecting of edible plants and burned for field crop. Since 1977, however, the lumbering, grazing and firing for fuel have been restricted and the plantations of ***Pinus rigida, Larix leptolepis*** and ***Diospyros kaki*** increased. The natural forest dominated by ***Quercus mongolica, Carpinus laxiflora*** and ***C. tschonoskii*** now remains on the extremely restricted area around the temples in the park area. These natural forests were expected to give us the informations about the distribution of natural

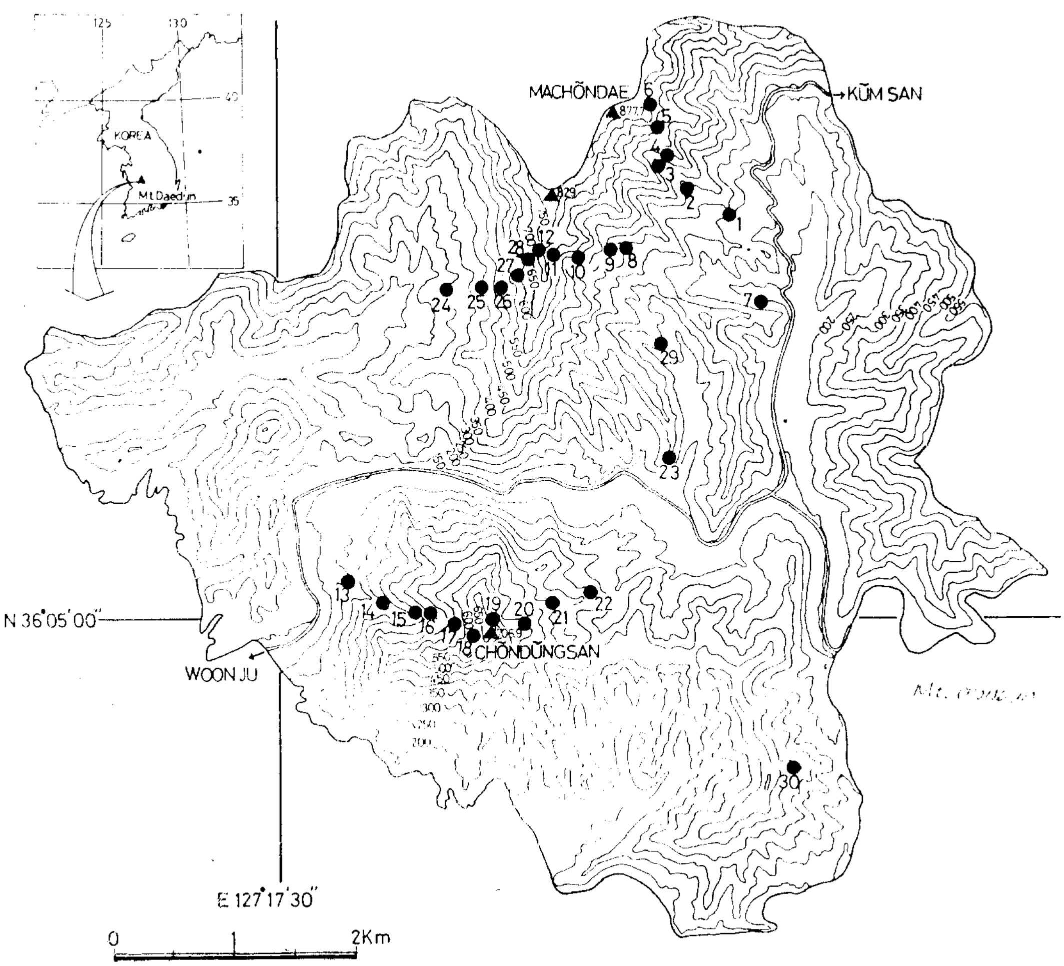

Fig. 1. Map showing the study sites. Arabic numerals under the black circles are relevé numbers as in Table 1.

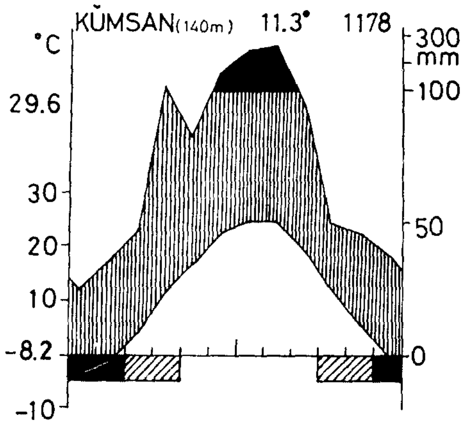

Fig. 2. Climate diagram of Kŭmsan near Daedunsan park area. The two curves chart monthly mean temperature (°C) and precipitation (mm); barring where the precipitation curve lies above the temperature curve presumably represents humid season and black area (mean monthly precipitation in excess of 100 mm) per humid season, and black boxes indicate months with a mean daily minimum below 0°C, cold season. Additional information in the figure includes elevation, mean annual temperature, mean annual precipitation, mean daily temperature maximum of the warmest month and mean daily temperature minimum of the coldest month.

vegetation in Honam area, Korea.

In this viewpoint, the phytosociological classification and environmental gradient analysis were applied to analyze the forest vegetation in Daedunsan provincial park area of Chŏllabukdo, Korea.

MATERIALS AND METHODS

Vegetation survey

With the Z-M method thirty relevés were selected at random (Fig. 1), and one quadrat (10 m × 10 m) was set randomly at every stand. Dominance and sociability occurred for vascular plant species and habitat conditions in each relevé were described (Braun-Blanquet, 1964; Werger, 1974; Suzuki *et al.*, 1985). The census for trees over 3 cm in DBH obtained from the quadrats were used for the ordination. The species were recorded according to Lee (1979). Soils collected from each quadrat were air-dried and sifted with a 20-mesh sieve for chemical analysis. Soil moisture content was calculated as a percentage of lost water against dry weight at 105°C. For climatic conditions Kira's warmth index 101.3°C·month(Yim and Kira, 1975), Thornthwaite's moisture index 62.8 (Yim and Kira, 1976), mean annual temperature 11.3°C and mean annual precipitation 1,178 mm (Fig. 2) based on the data of Kŭmsan meteorological station (Central Meteorological Office, 1984) were refered to discussion.

Tabulation

Plant communities were detected by classification method, tabular comparison of method Z-M school scheme (Küchler, 1967; Shimwell, 1971; Mueller-Dombois and Ellenberg, 1974; Suzuki *et al.*, 1985). To determine the vegetational units of the forest, the communities classified were compared with those of other region (Miyawaki *et al.*, 1983; Yim and Baik, 1985; Kim and Yim, 1986, 1988a).

Gradient analysis

For environmental pattern analysis temperature and moisture condition were used as the axes of charts on which vegetation types were plotted (Whittaker, 1956, 1967; Kim and Yim, 1988b). The ranks of mesic-xeric change in the area was determined with soil moisture content and/or topographic categories such as sheltered slopes and open slopes or coves and ridges. Soil moisture content was standardized in a scale of 1 to 10 for gradient analysis. Importance values calculated with relative density, relative coverage and relative frequency (Curtis and McIntosh, 1951) of trees were used for population chart. With the population charts, mosaic chart for vegetation pattern of Daedunsan park area was constructed.

Vegetation mapping

Based on the phytosociological classification, vegetation pattern and field surveys (Kim and Yim, 1987; Kim, 1987), the actual vegetation map of the area was made in scale 1: 25,000, and the potential natural vegetation map was made in scale 1 : 25,000, considering the actual vegetation map, physical conditions, plantation and fire records etc. (Küchler, 1967; Mueller-Dombois and Ellenberg, 1974; Suzuki *et al.*, 1985).

RESULTS AND DISCUSSION

Plant communities

The forest vegetation of the park area was divided into eight communities (Table 1).

A. *Acer mono-Zelkova serrata* community (Table 1:A)

This community on the stony slopes and mountain streamsides is distinguished from others by the presence of the differential species group 1 and 9 in Table 1. It seems to be topographic or edaphic climax conditions of the cool-temperate zone in the mountain, as Acero-Zelkovetum serratae Kim et Yim 1988 (Kim and Yim, 1988a) selected *Acer mono*, *Polysticum tripteron*, *Hydrangea serrata* for. *acuminata* and *Celtis sinensis* as character species of the association in Mt. Naejang. These species occur more abundantly in this community than in the other. The upper tree layer is chiefly composed of *Z. serrata*, which is often about 15 m tall and over 60 cm in DBH. The under tree layer is characterized by maple trees scattered, the shrub layer of 2 m high by *Staphylea bumalda* and the herb layer by poor species richness.

B. *Lindera erythrocarpa-Cornus controversa* community (Table 1:B)

This community on the mesic stony sites in the ravines is distinguished from others by the differential species group 2 and 9 but lacking of the group 7 and 8. It seems to be a topographic or edaphic climax conditions in this mountain as Corno-Linderetum erythrocarpae Kim et Yim 1988 of which the character species are *L. erythrocarpa*, *C. controversa*, *Arisaema amurense* var. *serratum* and *Alangium platanifolium* var. *macrophyllum* (Kim and Yim, 1988a).

C. *Carpinus tschonoskii* community (Table 1:C)

This community is distinguished from others by a differential species group 3 but lacking of the group 7 and 8. The community at elevations of below 400 m seems to be a climatic climax in the cool-temperate southern zone of the area. This community can be identified with the Carpinetum tschonoskii Kim et Yim 1986 belonging to the Carpinion laxiflorae Kim et Yim 1986 which is defined as the hornbeam forest developing in the cool-temperate zone of Korea by Kim and Yim (1986) who selected *C. tschonoskii, Acer pseudo-sieboldianum* var. *koreanum, Stephanandra incisa* and *Meliosma myriantha* as character species of the association.

D. *Quercus variabilis* community (Table 1:D)

This community is distinguished by the differential species group 4. It is a secondary forest which occurs on the sunny steep mountainside and xeric hillside. High constant species are *Lespedeza bicolor* and *Indigofera kirilowi.* The community seems to be closely related to the Quercetum variabilis Kim et Yim 1986, which is a topographic or edaphic climax community in the cool-temperate zone of Korea (Kim and Yim, 1986).

E. *Quercus serrata* community (Table 1:E)

This community is distinguished by the dominance of *Q. serrata,* the differential species. It is a secondary forest developed on the dry middle slopes of the mountain and mixed with the other oak species, *Q. variabilis* and *Q. mongolica.*

F. *Carpinus laxiflora* community (Table 1:F)

This community is distinguished by the differential species group 6 but lacking of the group 1. The community developing at elevations of 400 m~600 m seems to be a climatic climax in the cool-temperate middle zone of the mountain. This community can be identified with the Carpinetum laxiflorae Kim et Yim 1986 belonging to the Carpinion laxiflorae Kim et Yim 1986 as the differential species group 6 is similar to the character species of the association, *C. laxiflora, Vibrunum dilatatum, Symplocos chinensis* for. *pilosa* and *Rhus trichocarpa.*

G. *Rhododendron schlippenbachii-Quercus mongolica* community (Table 1:G)

This is distinguished from other communities by the presence of the differential species group 7 but lacking of the group 1, 2 and 8. This community at elevations above 600 m is a climatic climax of the cool-temperate zone in the area as Rhododendro-Quercetum mongolicae Kim et Yim 1988 belonging to the Acero-Quercion mongolicae Kim et Yim 1988 which is defined as the mongolian oak forest developing in the cool-temperate zone of Korea by Kim and Yim (1988a) who selected *Q. mcngolica, R. schlippenbachii, Melampyrum roseum* and *Ainsliaea acerifolia* as character species of the association. The upper tree layer is chiefly composed of *Q. mongolica* about 16m tall and over 27 cm in DBH and the under tree layer of maple trees scattered. The shrub layer of 2.5 m high is covered with *Acer pseudo-sieboldianum* and *R. schlippenbachii* and the herb layer is dominated by several ferns and sedges.

H. *Rhododendron mucronulatum-Pinus densiflora* community (Table 1:H)

This community is distinguished by the differential species group 8 and the dominance of *P. densiflora.* It occurs on the lower parts of the mountain which is destroyed by

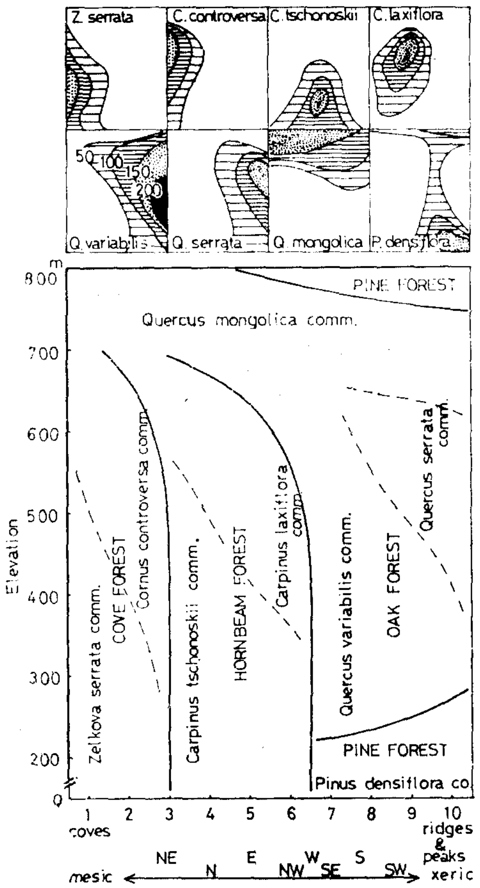

Fig. 3. Population charts(upper side) for eight dominant species and mosaic chart (under side) for vegetation pattern of Daedunsan park area. Arabic numerals on the lines stand for the isopleth of importance values of each species population. For the chart the vertical axis means the gradient of temperature and other factors related to elevation and the horizontal axis means the gradient of moisture relations and other factors from moist or mesic situations on the left to dry or xeric on the right, as affected by topographic position.

human activities or the hillock and exposed ridge line, dry and poor habitat. This community is similar to the Rhododendro mucronulati-Pinetum densiflorae Kim et Yim 1986 which is considered to be an edaphic climax on windy ridges and hillocks (Kim and Yim, 1986).

Vegetation pattern

The environmental pattern analysis by temperature and moisture gradient showed that the species are distributed continuously quite according to the principal of species individuality (Whittaker, 1951, 1956) and are arbitrarily grouped into sets of species having their population centers or modes close together (upper side of the Fig. 3). The distribution center was found at mesic-lower parts near the mountain stream and well drained stony slopes in *Zelkova serrata* population, *Cornus controversa* population at mesic stony sites of the ravines, *Carpinus tschonoskii* population at mesic-lower parts of the slopes, *Carpinus laxiflora* population at mesic-middle parts of the slopes, *Quercus variabilis* and *Quercus serrata* population at xeric-middle parts of the slopes, *Quercus mongolica* population at xeric-upper parts of the slopes and *Pinus densiflora* population at xeric-rock ridge line, hillock or poor habitat destroyed by human activities. Vegetation pattern of mosaic chart based on population charts was showed four vegetation types: cove forest with the dominant species of *Z. serrata* and *C. controversa* in coves and stony slopes, hornbeam forest with *C. tschonoskii* and *C. laxiflora* in lower-humid elevations, oakforest with *Q. serrata*, *Q. variabilis* and *Q. mongolica* in upper-xeric elevations and pine forest with *P. densiflora* in xeric hillsides and ridges (lower side of the Fig. 3).

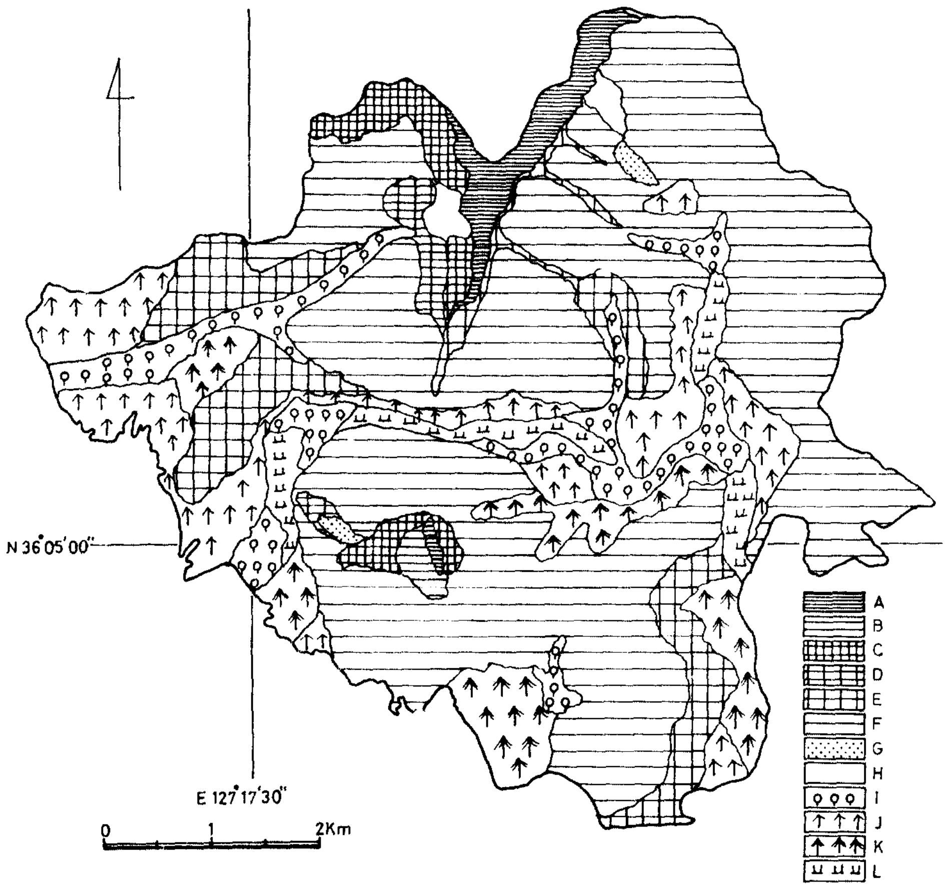

Fig. 4. The actual vegetation map of Daedunsan provincial park area. A : *Rhododendron schlippenbachii-Quercus mongolica* community, B : *Quercus serrata* community, C : *Carpinus laxiflora* community, D : *Carpinus tschonoskii* community, E : *Rhododendron mucronulatum-Pinus densiflora* communtiy, F : *Quercus variabilis* community, G : *Acer mono-Zelkova serrata* community, H : *Lindera erythrocarpa-Cornus controversa* community, I : *Diospyros kaki* plantation, J : *Pinus rigida* plantation, K : *Larix leptolepis* plantation, L : culture field.

Vegetation maps

The actual vegetation map (Fig. 4) showed five distributional types: *Quercus variabilis* and *Pinus densiflora* community on large area, *Carpinus laxiflora* and *Carpinus tschonoskii* community on restricted area around the temples, *Zelkova serrata* and *Lindera erythrocarpa-Cornus controversa* community on well drained stony slopes and ravines, *Quercus mongolica* and *Quercus serrata* community on xeric upper slopes and *Pinus rigida*, *Larix leptolepis* and *Diospyros kaki* plantation on the mountain foots and lower lands. *Q. variabilis* and *P. densiflora* forest are secondary forests after destroyed by human interferences and *C. laxiflora*, *C. tschonoskii* and *Q. mongolica* forests are the relic natural forests. *Pinus rigida*, *L. leptolepis* and *D. kaki* forest are planted for an erosion control, lumber and edibility, respectively.

Considering the actual vegetation map, climate, successional trends of trees (Kim and

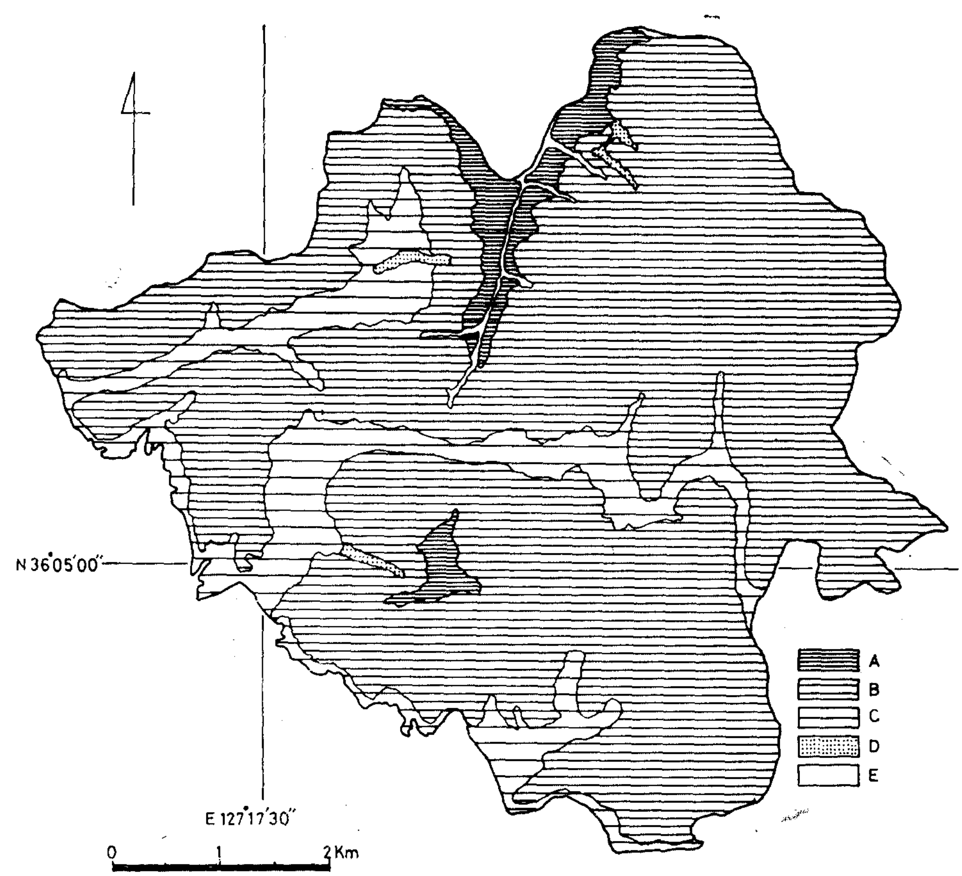

Fig. 5. The potential natural vegetation map of Daedunsan provincial park area. A : *Quercus mongolica* community, B : *Carpinus laxiflora* community, C : *Carpinus tschonoskii* community, D : *Zelkova serrata* community, E : *Pinus densiflora* community.

Yim, 1987 ; Kim, 1987) and topographic or edaphic climax conditions, it seems that potential natural vegetation of the area mainly composed of *Q. mongolica*, *C. laxiflora*, *C. tschonoskii*, *Z. serrata* and *P. densiflora* community(Fig. 5). By the examination of the two maps, actual vegetation map and potential natural vegetation map, the natural vegetation is mostly destroyed with exception of restricted area around the temples in this park. Therefore, the protection of natural vegetations and planned plantation for natural vegetations are required for the nature conservation.

摘 要

大芚山 道立公園의 森林植生을 分類法과 序列法으로 分析하였다. Z-M學派의 方法에 따라 同 公園의 森林植生은 고로쇠나무—느티나무, 층층나무—비목나무, 개서어나무, 굴참나무, 졸참나무, 서어나무, 철쭉꽃—신갈나무와 진달래—소나무의 8個 群落으로 分類되었다. 溫度—濕度傾度의 二次元分析에서도 이 8個의 群落이 서로 잘 分離되었으며 느티나무와 층

층나무, 개서어나무와 서어나무, 굴참나무와 졸참나무 그리고 신갈나무, 소나무를 各各 優占種으로 하는 溪谷林, 서어나무林, 참나무林, 소나무林의 4個의 植生型으로 類別되었다. 이와 같은 植物社會學的 分類와 環境傾度分析에 의한 現在植生 遷移段階, 極相林과 人間의 干涉程度를 把握하여 主로 신갈나무, 서어나무, 개서어나무, 느티나무와 소나무林이 分布할 것으로 보고 同 公園地域의 潛在自然植生圖(縮尺, 1 : 25,000)를 만들었다.

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Table 1. Synthesis table of forest communities on Daedunsan provincial park area, Korea

A. Acer mono – Zelkova serrata community
B. Lindera erythrocarpa – Cornus controversa community
C. Carpinus tschonoskii community
D. Quercus variabilis community
E. Quercus serrata community
F. Carpinus laxiflora community
G. Rhododendron schlippenbachii – Quercus mongolica community
H. Rhododendron mucronulatum – Pinus densiflora community

Community		A		B		C		D														E		F			G			H	
Serial number		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
Relevé number		2	14	5	27	13	25	24	8	15	1	10	9	7	23	3	4	11	22	21	20	17	18	26	19	16	28	6	12	29	30
Altitude(m)		400	250	650	600	150	400	300	400	350	300	550	450	200	250	500	550	650	300	400	500	500	600	500	600	400	650	770	720	250	350
Slope aspect		S	S	SE	NW	S	NW	W	SE	S	S	S	S	N	S	SE	SE	S	N	N	N	W	S	NW	N	S	NW	N	S	NE	S
Slope degree(°)		30	40	40	35	15	15	5	15	35	10	35	25	20	40	10	35	35	25	30	35	30	35	15	25	30	35	15	35	5	25
Topography		V	V	V	V	V	V	L	M	M	L	M	M	L	L	M	U	U	M	M	U	U	U	M	U	M	U	T	T	L	U
Quadrat size(m^2)		100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Height of tree-1 layer(m)		12	14	10	14	14	14	8	10	12	13	12	14	16	14	15	15	15	8	10	14	14	12	17	14	14	16	14	12	12	10
Coverage of tree-1 layer(%)		80	85	70	85	75	90	65	85	85	40	85	85	65	85	90	85	85	75	95	95	75	80	85	90	85	85	85	75	85	75
dbh of highest tree(cm)		27	23	23	23	28	19	15	15	15	21	21	26	26	21	27	23	18	15	20	17	27	23	26	18	25	27	18	18	22	18
Height of tree-2 layer(m)		8	8	7	8	8	8	5	5	8	8	8	8	8	7	8	10	8	5	6	8	8	8	8	9	8	8	8	8	6	6
Coverage of tree-2 layer(%)		55	40	75	88	70	60	35	60	45	85	40	45	80	40	65	60	65	55	90	90	55	55	80	95	80	80	70	65	70	70
Height of shrub layer(m)		2	2	2	2	3	3	2	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2.5	2.5	2	2	2	2
Coverage of shrub layer(%)		40	60	45	50	80	70	95	95	85	80	35	60	95	45	70	45	90	100	75	75	55	65	70	75	65	60	75	70	95	75
Height of herb layer(m)		0.5	0.5	0.8	0.8	0.8	0.5	0.8	0.5	0.5	0.5	0.5	0.5	0.5	0.8	0.5	0.5	0.5	0.5	0.8	0.8	0.5	0.5	0.5	0.8	0.5	0.8	0.8	0.8	0.8	0.5
Coverage of herb layer(%)		30	30	60	65	85	40	90	65	45	65	60	35	90	55	55	75	40	95	80	85	35	25	40	100	35	85	95	75	80	60
Number of species		42	33	27	18	43	39	42	18	23	51	14	27	43	20	40	21	32	26	22	26	33	25	28	19	30	24	21	19	40	25
Differential species groups																															
1																															
Zelkova serrata	T1:	3.3	3.3	.	.	1.1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.1	.	.
	T2S:	1.2	1.2	.	.	.	.	.	.	.	.	.	.	±	.	+	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.
Acer mono	T1:	1.2	.	.	+	.	1.1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.
	T2S:	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	±	.	.	.	.	.
Celtis sinensis	T1:	.	1.1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hydrangea serrata for. acuminata	S:	+	.	.	+	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	.	.	.	.	+	.	.	.	.
2																															
Cornus controversa	T1:	1.2	.	3.2	3.3	+.1	.	.	.	.	.	.	.	.	.	2.2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	T2S:	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	±	.	.	.	.	.	.	.	.	.
Lindera erythrocarpa	T1:	+	+	1.1	2.2	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
	T2:	.	.	2.3	2.2	.	.	.	.	.	.	.	2.2	.	.	.	.	.	.	.	.	+	+	+	+	.	+	.	+	.	.
	S:	.	+	+	1.2	1.2	.	.	.	.	r	.	.	+	.	.	+	.	.	.	.	.	.	+	.	+	+	.	2.2	+	+
Alangium platanifolium var. macrophyllum	S:	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
3																															
Carpinus tschonoskii	T1:	.	.	.	.	3.1	4.4	.	.	.	.	.	.	.	.	+	.	+	.	+	.	1.1	.	.	.	1.1	.	.	+	.	.
	T2:	.	.	.	.	.	2.3	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	+	.	.
	S:	.	.	.	.	+	1.2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	+	.
Stephanandra incisa	S:	.	.	+	.	2.3	+	+	.	.	.	.	.	1.2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Acer pseudo-sieboldianum var. koreanum	S:	.	.	.	.	+	+	+	.	.	+	.	.	.	+	.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.
4																															
Quercus variabilis	T1:	.	+	.	.	.	1.1	3.3	4.4	4.4	2.2	5.5	3.3	3.2	4.4	3.3	4.4	3.3	4.4	5.5	5.5	1.2	1.2	1.2	1.2	1.1	1.1	.	+	.	.
	T2:	.	.	.	.	.	.	2.3	1.2	+	3.3	2.2	.	.	1.2	1.2	1.2	.	2.2	3.3	.	.	.	+	.	+	.	.	.	.	1.2
	S:	.	+	.	.	.	+	3.3	1.3	+	.	1.2	.	.	.	.	+	+	3.3	1.2	+	+	.	+	.	+	.	.	.	+	.
Lespedeza bicolor	S:	.	+	+	.	+	+	+	2.3	3.3	+	+	2.3	1.2	+	+	2.3	2.3	2.3	1.2	+	+	2.3	+	+	+	.	.	.	2.3	.
Indigofera kirilowii	H:	.	+	.	.	+	.	+	.	.	+	2.3	.	+	.	.	.	+	.	.	+	.	.	.	.	.	.	+	.	.	.
5																															
Quercus serrata	T1:	.	.	1.1	1.1	+	.	.	.	+	.	.	.	+	1.2	.	2.2	+	.	1.2	+	3.3	3.3	2.2	.	1.1	1.1	1.2	+	+.1	1.2
	T2:	.	.	.	.	.	+	.	+	.	1.2	.	.	+	1.2	.	.	.	1.2	.	+	+	+	.	.	+	.	.	.	.	.
	S:	.	.	.	.	.	+	2.3	+	.	1.3	.	.	+	.	.	+	.	2.2	+	+	+	.	.	.	.	.	.	.	+	+
6																															
Carpinus laxiflora	T1:	.	.	1.1	.	.	.	.	.	.	.	.	.	+	.	.	.	+	.	+	+	.	.	3.3	4.4	3.3	.	.	.	.	.
	T2:	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	.	2.3	1.2	.	.	.	3.3	.	1.2	+	.	.	.
	S:	.	.	.	+	.	.	.	.	.	.	.	.	2.2	.	.	.	+	.	1.2	2.2	.	.	.	.	.	.	.	.	.	+
Viburnum dilatatum	S:	+	.	+	+	.	+	+	.	.	.	.	.	1.2	.	+	.	.	+	.	.	+	+	+	+	+	+	+	.	+	+
Rhus trichocarpa	T2S:	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	+	.	.	.	+	+	±	.	.	.	.	.	.
7																															
Quercus mongolica	T1:	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.2	1.2	.	2.2	.	3.3	4.4	3.3	.	.
	T2:	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	.	.	.	.	.	2.3	1.2	.	.	.
	S:	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	.	.	.	.	.	2.3	.	.	.	.
Acer pseudo-sieboldianum	T1T2:	.	.	± +	.	.	.	.	.	.	.	.	.	.	.	1.2	.	.	.	.	.	.	1.2	+	.	1.2	1.2	2.3	1.2	.	.
	S:	.	.	.	.	.	.	+	.	.	.	.	.	.	+	.	.	+	.	.	.	+	.	2.2	+	+	2.3	+.2	.	.	.
Rhododendron schlippenbachii	S:	.	.	+	.	.	.	.	.	.	.	+	.	.	+	.	+	+	+	.	+	.	+	.	+	.	.	+	+	.	.
Ainsliaea acerifolia	H:	+	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	+	.	+	2.3	+	.	+	.	.	2.3	.	+	.	.
8																															
Pinus densiflora	T1:	.	.	.	.	.	.	.	+	.	.	+	.	.	+	.	.	.	.	.	.	.	+	.	.	+	.	.	.	4.4	3.3
	T2S:	.	.	.	.	.	.	±	.	+	+	.	.	.	.	.	.	.	±	.	.	.	.	.	.	.	.	.	.	+	+.2
Rhododendron mucronulatum	S:	.	.	.	.	.	+	.	.	.	+	1.2	.	.	.	+	1.2	.	+	+	+	.	+	.	1.3	.	.	.	.	+	1.2
Rhus verniciflua	T2S:	.	.	.	.	.	±	.	.	.	.	.	.	± +	.	.	.	± +	.	+	2.2	.	.	.	.	.	.	.	.	+	+
Milium effusum	H:	+	1.2	.	.	.	+	+	+	2.2	+	+	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	+	+
Festuca ovina	H:	.	.	+	.	+	+	+	+	.	+	+	.	.	.	2.3	2.3	3.3	+	+	+	2.3	2.3	.	+	+	.	.	.	2.3	+
9																															
Staphylea bumalda	T2S:	2.3	+	± +	.	.	.	.	.	.	.	.	+	±	.	+	.	.	.	.	.	+	.	1.2	.	+	+	2.3	+	.	.
Zanthoxylum piperitum	S:	+	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Thalictrum actaefolium	H:	+	.	.	+	.	+	.	.	+	.	.	2.3	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Oplismenus undulatifolius	H:	+	+	.	.	.	+	.	.	.	.	.	+	.	.	+	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.
10																															
Lindera obtusiloba	T1T2:	.	+	+	.	± +	.	.	.	.	.	.	.	.	.	+	.	2.3	.	+	+	.	.	2.2	2.2	2.2	.	+	.	.	.
	S:	+	.	.	+	+	+	.	.	.	.	.	+	+	1.2	3.3	.	.	.	+	2.2	+	+	2.3	+	2.3	1.2	.	1.2	+	.
Styrax japonica	T2S:	±	.	.	.	± +	.	+	.	.	+	.	.	.	.	.	.	.	.	+	+	± +	.	1.2	.	.	.	.	±	.	1.2
Euonymus sachalinensis	T2S:	+	+	.	.	+	.	.	.	.	+	.	.	.	.	± +	.	.	.	.	.	+	.	.	.	+	.	.	.	.	.
Sapium japonicum	T2:	.	.	+	+	.	.	.	.	+	.	.	+	.	.	1.2	.	+	.	.	.	+	+	+	2.2	.	.	.	.	.	.
	T1S:	+	.	.	.	.	.	.	.	+	.	.	+	.	+	± +	.	.	.	.	.	2.3	+	+	2.3	.	.	.	.	.	.
Styrax obassia	T2:	.	+	.	.	.	.	.	.	.	.	.	.	1.2	.	+	2.2	2.2	.	+	2.2	1.2	2.2	.	1.2	2.3	.	1.2	.	.	.
	T1S:	.	.	.	.	.	.	.	.	.	.	.	.	± +	.	1.1	+	.	.	+	+	+	2.3	.	.	2.3	.	.	+	.	.
11																															
Fraxinus rhynchophylla	T1T2:	± +	± +	+	.	.	+	+	.	1.2	+	.	+	1.2	.	.	.	1.2	.	.	.	.	.	.	.	+	.	+	.	+.2	.
	S:	.	+	.	+	.	+	.	.	+	+	.	.	+	.	+	.	2.3	.	.	.	+	.	+	.	.	.	.	.	.	.
Prunus sargentii	T1T2:	.	.	.	±	+	±	.	.	.	± +	.	1.2	± +	.	2.2	.	±	.	.	.	2.2	.	.	1.2	.	.	.	.	1.2	.
Carex siderosticta	H:	.	.	.	.	.	+	.	.	+	+	.	.	1.3	1.3	.	.	.	2.3	2.3	+	.	+	.	.	.	1.2	+	.	3.3	3.3
Smilax china	H:	+	+	.	.	+	+	+	+	.	+	.	.	+	+	+	+	+	+	+	+	.	.	.	.	+	.	.	+	+	+
Disporum smilacinum	H:	+	.	.	+	.	+	.	1.3	+	.	+	.	.	+	+	.	+	2.3	+	+	.	.	2.3	.	.	.	+	.	+.2	2.3
Viola acuminata	H:	+	.	.	.	.	+	.	.	.	.	.	.	+	.	+	.	.	+	.	.	+	.	+	.	.	+	.	.	.	.

Companions																															
Carex lanceolata	H:	+	+	+	.	+	+	+	+	.	+	.	+	+	+	+	.	+	.	.	+	+	+	+	.	+	+	.	.	+	+
Pteridium aquilinum var. latiusculum	H:	.	.	+	+	.	.	+	+	.	+	.	.	+	.	+	+	.	+	+	3.3	+	.	.	+	.	+	+	.	+	+
Platycarya strobilacea	T1:	.	.	.	+	+	.	.	1.2	.	.	+	.	+	1.2	+	+	+	.	.	.	+	.	.	.	2.2	.	.	.	.	.
	T2S:	.	+	.	.	.	.	.	+ ±	.	r	+	.	+	+ ±	+	.	.	.	1.2	2.3	.	.	.	.	±	.	.	.	±	±
Aster scaber	H:	.	+	.	.	+	1.2	+	+	.	+	.	+	+	.	+	+	+	+	.	.	+	.	.	.	.	+	.	.	.	.
Quercus aliena	T1T2:	.	.	.	.	±	+	±	+ ±	+	1.2	.	1.2	+	.	.	1.2	±	.	1.2	.	.	.	.	.	.	.	.	+	1.2	.
	S:	.	.	.	.	+	+	.	1.2	.	1.3	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	2.3	.
Zanthoxylum schinifolium	T2S:	.	± +	±	.	r	.	.	+	+	+	.	+	.	.	.	.	.	+	.	.	r	.	+	.	r	±	.	.	.	.
Sasa borealis	H:	.	.	1.2	3.3	2.2	.	+	.	.	.	.	.	.	1.2	.	.	.	1.2	3.3	4.4	.	.	.	5.5	.	4.4	5.5	4.4	.	.
Melampyrum roseum	H:	.	.	.	.	.	+	.	+	.	.	+	.	.	.	.	+	+	+	+	+	.	+	.	.	.	.	.	.	+	+
Smilax sieboldii	H:	+	.	.	.	+	+	.	.	.	.	.	+	+	+	+	.	.	.	.	.	.	.	.	.	.	.	+	+	+	+
Cocculus trilobus	H:	.	+	.	.	+	+	+	+	.	.	.	+	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	+	+
Rhus chinensis	T2S:	.	± +	.	.	+	.	.	.	+	r	+	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	+	+
Lysimachia clethroides	H:	.	+	.	+	+	.	+	.	.	+	+	.	.	.	+	.	.	.	.	.	.	.	.	.	+	.	.	.	+	+
Isodon inflexus	H:	+	.	.	.	+	.	+	+	.	.	.	+	+	.	+	.	.	.	.	.	.	+	.	.	.	.	+	.	+	.
Pyrola japonica	H:	.	.	.	.	.	+	.	.	.	.	.	.	+	+	.	+	+	.	.	1.2	.	.	.	.	.	.	.	.	.	+
Smilax nipponica	H:	.	.	.	+	+	+	+	.	.	+	.	.	.	.	.	.	+	.	.	.	.	.	+	.	.	+	.	.	.	.
Artemisia keiskeana	H:	.	+	.	.	.	.	+	.	.	.	.	.	.	.	+	+	.	.	.	.	+	+	.	.	.	.	.	.	.	.
Miscanthus sinensis var. purpurascens	H:	.	.	.	.	.	.	1.2	.	+	2.3	.	.	.	.	.	.	.	2.3	.	.	.	.	.	.	.	.	.	.	+	.
Castanea crenata	T2:	.	.	.	.	+	+	+	.	.	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
	T1S:	.	.	.	.	.	+	±	.	.	.	.	.	2.2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	±	.
Corylus heterophylla var. thunbergii	S:	+	.	.	.	+	.	.	+	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.
Rubus crataegifolius	S:	.	+	+	.	.	.	.	.	+	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	+	.	.	.	.	.
Securinega suffruticosa	S:	.	+	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	+	.	.	.	+	.	.	.	.	.
Ligustrum obtusifolium	S:	+	.	.	.	.	.	.	.	.	.	.	+	+	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
Atractylodes japonica	H:	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	+	.	.	.	.	.	.	.	.	+	.
Cephalanthera longibracteata	H:	.	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	+	.
Sanguisorba officinalis	H:	.	.	.	.	.	.	.	.	.	+	.	.	+	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	+	.
Pueraria thunbergiana	H:	+	.	.	.	.	+	.	.	.	+	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Arabis glabra	H:	.	.	.	.	.	.	+	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.
Artemisia sylvatica	H:	.	.	.	.	+	+	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.
Rubus oldhamii	H:	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	+	+	.	.	.	+	+	.	.	.
Boehmeria tricuspis	H:	+	+	+	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Albizzia julibrissin	S:	.	.	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+
Clerodendron trichotomum	T2S:	.	±	.	.	+	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.
Galium gracilens	H:	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	+	+	.
Gentiana scabra var. buergeri	H:	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+
Synurus deltoides	H:	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	.	+	.	+	.	.	.	.	.	.	.	.	.	.
Dioscorea batatas	H:	+	+	.	.	+	.	.	.	.	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Arthraxon hispidus	H:	.	+	.	.	+	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Youngia denticulata	H:	.	+	.	.	.	.	.	.	+	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	+	.	.	.	.	.
Thesium chinense	H:	.	.	.	.	.	+	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	+	.	.	+	.	.	.	.
Parthenocissus tricuspidata	H:	+	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.
Davallia mariesii	H:	.	.	+	.	+	.	.	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Euonymus alatus	S:	+	.	.	.	.	.	+	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Rosa multiflora	S:	.	.	.	.	.	.	+	.	.	r	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Malus baccata	T1S:	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	1.1	1.1	.	.	.
Hemerocallis fulva	H:	.	.	.	.	.	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Platycodon grandiflorum	H:	.	.	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Viola dissecta var. chaerophylloides	H:	.	.	.	+	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Artemisia princeps var. orientalis	H:	.	.	.	.	+	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ostericum sieboldii	H:	+	.	.	.	.	.	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Polygonatum odoratum var. pluriflorum	H:	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.
Peucedanum terebinthaceum	H:	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Saussurea seoulensis	H:	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.
Vitis amurensis	H:	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.
Thalictrum aquilegifolium	H:	+	.	.	.	+	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Paris verticillata	H:	+	.	.	.	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.

Rare species: Pinus rigida(29:T1,S–+), Pyrus pyrifolia(24,29:T2–+), Quercus dentata(29:S–2.3), Prunus davidiana(10:T2–+), Aralia elata(3:T2–+, 5:S–r), Acer ginnala(10:S–r), Alnus hirsuta(10,11:S–+), Larix leptolepis(13,18:S–+), Sorbus alnifolia(9:S–r), Ilex macropoda(2,21:S–+), **Diospyros** kaki(13:T1–+), Malus sieboldii(13:S–+), Syringa wolfi(26:S–+), Rubus coreanus(1,15:S–+), Meliosma oldhamii(12,21:T2–+), Carpinus cordata(23:T1–1.1), Morus bombysis(3:T2–+), Kalopanax pictus(3:T2–+), Actinidia arguta(3:S–1.1), Cephalotaxus koreana(28:S–+), Potentilla fragarioides var. major(29:H–+), Clematis mandshurica(2,29:H–+), Hosta lancifolia(10,24:S–+), Liriope platyphylla(10:H–+), **Adenophora** triphylla var. japonica(10,18:H–+), Veratrum maackii var. japonicum(10:H–+), Hosta minor(10:H–+), Setaria viridis(9,10:H–+), Zoysia japonica(7:H–+), Imperata cylindrica var. koenigii(7:H–+), Agrimonia pilosa(7,13:H–+), Artemisia japonica(7:H–+), Arundinella hirta(7:H–1.3), Osmunda japonica(7,18:H–+), Cirsium japonicum var. ussuriense(7:H–+), Solidago virga-aurea var. asiatica(7:H–+), **Themeda** triandra var. japonica(7:H–+), Polygonum aviculare(7:H–+), Codonopsis lanceolata(18:H–+), Sedum kamtschaticum(9:H–+), Patrinia scabiosaefolia(9:H–+), Clematis apiifolia(14:H–+), Lilium amabile(18:H–+), Lonicera japonica(13:H–+), Lastrea thelypteris(6,13:H–+), Duchesnea chrysantha(13:H–+), Elsholtzia splendens(13,15:H–+), Galium trachyspermum(20:H–+), Vitis thunbergii var. sinuata(22:H–+), Chrysanthemum zawadskii var. latilobum(22:H–+O, Sedum polystichoides(17:H–+), Dryopteris crassirhizoma(26:H–+), Asparagus schoberioides(5,23:H–+), Dioscorea nipponica(5:H–+), Bidens bipinnata(5:H–+), Lastrea laxa(5:H–+), Clematis trichotoma(2,12:H–+), Vicia unijuga(1:H–+), Boehmeria nivea(2:H–+), Clematis apiifolia(1:H–+), Adenocaulon himalaicum(1:H–1.3), Akebia quinata(1:H–+), Arisaema amurense var. serratum(12:H–+), Ranunculus tachiroei(12:H–+), Cayratia japonica(12:H–+), Rubia akane(3,23:H–+).

Date of survey: Relevé No.1–6;Oct.9,1985, No.7–12;Oct.12,1985, No.13–23;Oct.13,1985, No.24–30;Oct.20,1985.

Note: L; lower part of slope, M; middle part of slope, U; upper part of slope, V; valley, T; top. T1; tree-1 layer, T2; tree-2, S; **shrub**, H; herb.