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Classification and Ordination Analysis on the *Quercus mongolica* Communities in Mt. Changan, Chŏnbuk[1*]

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분류법과 서열법에 의한 전북 장안산의 신갈나무 군락 분석[1*]

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ABSTRACT

A studty of *Quercus mongolic*a forest in Mt. Changan was investigated by classification and ordination method. By classification methods, 3 communities were recognized as followed: *Quercus mongolica-Rhododendron schlippenbachi*i, *Quercus mongolica-Symplocos chinensis* for. *pilosa* and *Quercus mongolica-Sasa borealis* communities. According to the result of CCA(canonical correspondence analysis) *Quercus mongolica*, *Rhododendron schlippenbachii* and *Symplocos chiensis* for. *pilosa* were situated in the high altitude region with good organic matter. *Acer mono*, *Fraxinus mandshurica*, *Philadelphus schrenckii*, *Magnolia sieboldii* and *Carpinus cordata* were distributed throughout the valley with high soil moisture and good nutrient. And *Pinus densiflora*, *Quercus variabilis*, *Rhus chinensis* and *Weigela subsessilis* were found in the low altitude region. The importance value(I.V.) of *Quercus mongolica* forest was strongly correlated with altitude, soil moisture, organic matter, topography and pH.

KEY WORDS : ALTITUDE, ORGANIC MATTER, SOIL MOISTURE, CCA

요 약

전북 장안산의 신갈나무림을 분류법과 서열법에 의하여 분석하였다. 분류법(식물사회학적 방법)에 의한 신갈나무림의 분석결과 신갈나무-철쭉꽃군락, 신갈나무-노린재나무군락, 신갈나무-조릿대군락의 3개 군락으로 분류되었다. CCA에 의하여 분석된 결과에 의하면 신갈나무, 철쭉꽃, 노린재나무는 고도가 높은 지역에서 분포하고, 고로쇠나무, 들메나무, 고광나무, 함박꽃나무, 까치박달은 습하고 유기물 함량 및 전질소, C.E.C 등의 양료가 양호한 지역에, 소나무, 굴참나무, 붉나무, 병꽃나무는 고도가 낮은 지역에서 분포하고 있다. 신갈나무림의 분포

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와 환경과의 상호관계를 분석한 결과 고도, 토양습도, 유기물함량, 지형, pH 등이 높은 상관관계를 나타냈다.

주요어 : 고도, 유기물함량, 토양습도, CCA

INTRODUCTION

The earlist systematic description of vegetation was by the Humboldt(1805) who classified area dominated by plants of similar growth form into vegetation types. More detailed and better defined descriptions and classification were developed by Schouw(1823), Kerner(1863), and Grisebach(1872).

Grisebach had applied the term formation to a community of plant and Fllahault(1893) had established the term association as an unit of vegetation.

Two aspects of vegetation type have been widely used in formation concept by physiognomy and phytosociology by species composition (Mueller-Dombois and Ellenberg, 1974).

The study of vegetation had been developed largely extending from the last nineteenth century to the early twentieth century. Particularly, Braun-Blanquet school has produced an enormous body of work on the vegetation of Europe within a coherent scheme of vegetation study.

Somewhat, the British and American schools by Curtis, McIntosh, and Whittaker established recognition of vegetational continuity and of species population opposed to an unit of vegetation developed to phytosociology.

Mueller-Dombois and Ellenberg(1974) writted 'Vegetation Ecology' attempted to synthesize two methods, classification of the Continent school and ordination of British and American school.

Ordination was divided into direct ordination by environmental gradient analysis of Whittaker(1951) and indirect ordination by continuum index of Curtis and McIntosh(1951), but since then has developed many methods.

A conception of differential species distribution along environmental gradient has been central to development of generalized models in community ecology(Clements, 1916; Diamond, 1978; Whittaker, 1967).

Particularly, canonical correspondence analysis(CCA) as a multivariate extention of weighted averaging ordination is a simple method for arranging species along environmental variables(ter Braak, 1987).

These classification and ordination methods have advanced greatly since 1950 and have used continuously until the present by many ecologists, such as, Dooley and Collins(1984), Kim and Yim(1986a; 1986b), Kim and Kil(1991) and so on.

In this point of views this study aims at : (1) describing the Quercus mongolica forest vegetation type in Mt. Changan, Chŏnbuk base on differential species investigated by Z-M method, and (2) understanding the ecological relationships between the forest vegetatoion and the environment, using canonical correspondence analysis(CCA) method.

METHODS

1. Vegetation data and environmental data

Quantitative floristic data were obtained during April 1997~September 1998 from 40 sample plots. Size, 15m×15m minimal area in size, was set randomly at every relevé(Oosting, 1956).

Among 40 sample plots classification analysis data were obstianed from the number. Ordination analysis data were obtained from the numbers and black circles.

Representative stands were selected on the

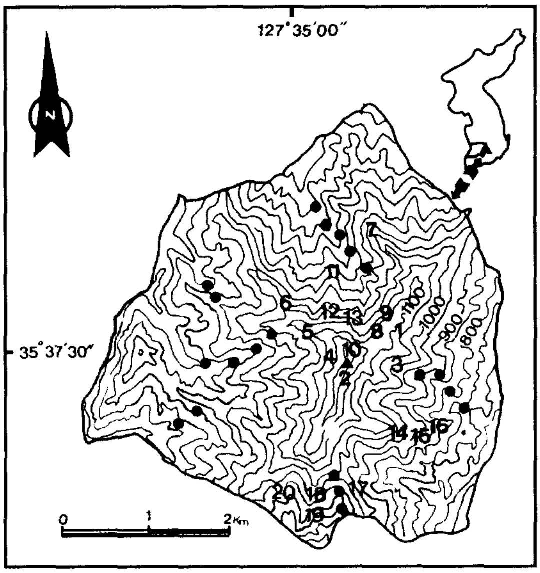

Figure 1. Sampling sites in Mt. Changan (Number : Sampling sites connected classification analysis. Number and black circle : sampling sites connected ordination analysis

basis of homogeneity and visually checked for uniformity in floristic composition.

The vegetation description was based on the complete floristic composition of the plant communities following Braun-Blanquet(1964).

Domoniance and sociability value were estimated for every releé following the Braun-Blanquet scale. The plant name was recorded according to Lee(1979).

Soil samples were obtained from the place with the community. Soil samples were collected with a gouge auger(diameter 5.08cm) from a horizon. Three cores were homogenized into one sample and in each station three such samples were taken. Samples were air-dried and weighted(fresh weight and dry weight) prior to analysis.

The following chemical analyses were performed. Soil moisture content was calculated as a percentage of loss water against dry weight at 105℃. Soil organic matter content was determined as a percentage of the loss-on-ignition against dry weight by Allen et al.(1991) method (Moore and Chapman, 1986). Soil pH was determined in solution(soil : dist. water = 1 : 5, W/V) by glass electrode.

Cation exchange capacity(Brown' s method) and potassium content(flame photometry) were determined. Other analyses of soil components were done by soil chemical analyses(Rural Development Administration, 1988). Soil analyses were carried out at the Soil Laboratory of the Rural Development Administration, Korea.

For site description, the altitude, slope, aspect (N, E, S, W, NE, SE, SW, NW) and topography (ridgeline, slope, valley) of each releé were determined.

2. Data analysis

In order to obtain an effective description of community type and their environmental correlation, we used the classification and ordination techniques.

Plant communities were detected based on the data obtained from fields by classication method, tabular comparison method of Z-M school scheme(Küchler, 1967; Mueller-Dombois and Ellenberg, 1974; Suzuki et al., 1985)

CCA, a multivariate extention of weighted averaging ordination, was performed including 8 environmental variables.

The axes were extracted by CCA represent those directions of variation in species composition that are related to supplied external variables.

CCA was performed with procedures in the program-package CANOCO(ter Braak, 1988).

RESULTS AND DISCUSSION

1. Classification analysis

Quercus mongolica forest of Mt. Changan is distinguished from others by the presence of *Quercus mongolica*, *Acer pseudo-sieboldianum*, *Fraxinus sieboldiana*, *Tripterygium regelii*, *Carex okamotoi* and *Carex siderosticta*, the differential species.

This forest on elevations above 600m at sea level of the mountain seems to be in a climatic climax condition in northern parts of the cool-temperate zone of Korea. This can be identified as Rhododendro-Quercetum mongolicae Kim and Yim 1988 belong to Acero-Quercion mongolicae Kim and Yim 1988, considering the character species of the association, *Quercus mongolica*, *Rhododendron schlippenbachii*, *Melampyrum roseum* and *Ainsliaea acerifolia* which occur abundantly in this community(Kim and Yim, 1988). The habitats of this forest in the study area were found at higher altitude above 800m.

The tree layer of this forest is chiefly composed of *Quercus monglica* about 9~16m height and 75~95% coverage. The vegetation of *Quercus mongolica* forest was divided into three communities by tabular comparison method of Z-M school scheme. A brief description of the plant communities and characteristics of species composition follows.

(1) *Quercus mongolica-Rhododendron schlippenbachii* community(Table 2-A)

The distribution of this community in Mt. Changan is mainly between 1,000m and 1,200m high. This is distinguished from other community by the presence of the differential species of Table 2. The plant community is dominated mostly by *Quercus mongolica*, *Rhododendron schlippenbachii*, *Acer pseudo-sieboldianum*, *Ainsliaea acerifolia*, *Carex okamotoi* and *Carex lanceolata* in the tree, subtree and herb layers, respectively. The stems are 10~20cm in DBH (diameter at breast height) and generally attain a height of 10~13m of tree layer. The mean number of species was calculated as 23 spp./relevé.

(2) *Quercus mongolica-Symplocos chinensis* for. *pilosa* community(Table 2-B)

In Mt. Changan, this community is located from medium slopes to upper slopes between 900m~1150m high. This is distinguished from other communities by the dominance of *Symplocos chinensis* for. *pilosa*, the differential species of Table 2. The associated trees and shrubs include *Lespedeza maximowiczii*, *Fraxinus*

Table 1. Description of the physical features and stratum of each quadrat in Mt. Changan

Serial number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Altitude(m)	1080	1200	1000	1140	1070	950	900	1100	1080	1150	830	975	960	980	910	890	910	980	830	900
Slope aspect	SSE	NNW	SE	NNE	NE	SSE	NNW	SSW	SSW	WS	NW	ES	SSW	SSE	EN	SW	SE50	SE50	SW40	WN40
Slope degree(°)	40	35	35	35	40	40	10	45	20	35	25	50	35	10	25	25	15	35	25	35
Topography	M	M	U	U	U	M	M	M	M	U	L	M	M	U	M	M	U	U	M	M
Quadrat size(m^2)	225	225	225	225	225	225	225	225	225	225	225	225	225	225	225	225	225	225	225	225
Height of tree-1 layer(m)	12	12	13	10	10·	13	14	12	12	9	14	14	14	14	13	13	10	10	16	13
Coverage of tree-1 layer(%)	85	90	85	85	95	90	85	90	85	85	80	85	90	90	80	85	80	75	90	90
Height of tree-2 layer(m)	6	5	7	4	6	4	7	6	5	7	7	6	4	5	6	6	5	6	5	7
Coverage of tree-2 layer(%)	50	40	40	70	65	35	50	5	50	50	35	55	5	10	60	20	15	40	5	60
Height of shrub layer(m)	1.2	1.2	1.5	1.0	1.0	1.2	1.2	1.7	1.2	1.2	0.9	0.9	0.9	0.9	1.0	0.9	1.5	1.3	1.7	1.7
Coverage of shrub layer(%)	5	15	40	3	3	55	40	65	50	35	10	15	20	10	5	15	20	15	30	10
Height of herb layer(m)	0.3	0.2	0.5	0.2	0.2	0.3	0.3	0.4	0.3	0.6	0.7	0.6	0.6	0.6	0.7	0.7	0.5	0.5	0.7	0.7
Coverage of herb layer(%)	60	80	20	85	75	20	40	50	60	85	90	95	85	90	85	75	85	70	95	98
Number of species	24	21	21	27	20	30	27	30	17	23	29	35	12	15	21	20	28	24	9	18

Note : Serial number is same as serial number of Table 2.

Table 2. Vegetation table of *Quercus mongolica* forest in Mt. Changan

Community		A					B					C										Common name
Serial number		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Differential species of *Quercus mongolica* community group																						
Quercus mongolica	T1	4.4	5.5	3.3	4.4	5.5	5.5	4.4	5.5	5.5	5.5	4.4	4.5	5.5	5.5	4.4	3.3	3.3	3.3	3.3	2.2	신갈나무
	T2	.	+	.	1.1	.	1.2	2.3	.	+	1.1	2.2	+	+	+	.	.	.	.	.	3.4	
	S	.	.	.	.	.	.	.	.	.	.	+	.	.	+	.	.	.	.	.	.	
Acer pseudo-sieboldianum	T1	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	.	.	당단풍
	T2	2.2	+	2.2	+	1.1	+	+	.	+	1.2	+	.	.	1.1	+	.	+	2.2	.	.	
	S	.	+	+	.	+	.	+	.	+	+	+	.	.	.	+	.	.	+	.	.	
Fraxinus sieboldiana	T1	.	.	.	.	.	.	.	.	+	.	.	+	.	.	+	.	.	.	.	.	쇠물푸레
	T2	.	.	.	.	1.1		.	+	+	1.2	3.3	+	.	.	3.3	.	.	.	.	.	
	S	.	.	.	.	.	.	.	.	+	+	+	.	.	.	+	.	.	.	.	.	
Tripterygium regelii	S	+	.	.	+	+	.	.	.	.	+.2	.	+.2	.	+	.	+	+	.	.	.	미역줄나무
Carex okamotoi	H	+.2	4.5	+.2	.	.	.	.	.	2.2	+	+	.	.	.	.	.	.	+	.	.	지리대사초
Carex siderosticta	H	1.2	+.2	+.2	1.2		+	1.2	.	3.3	.	.	+.2	.	+	.	.	.	+.2	.	.	대사초
Melampyrum roseum	H	.	+	+	+	.	+.2	+.2	3.3	.	+.2	+	.	.	+	.	.	.	.	.	+	꽃며느리밥풀
Differential species of community																						
Rhododendron schlippenbachii	T2	1.2	3.3	3.4	3.3	3.3	.	.	.	.	+.2	.	.	.	.	.	.	.	.	.	2.3	철쭉꽃
	S	.	+	1.1	+	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	3.3	
Rhododendron mucronulatum	T2	.	.	+	.	+.2	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	진달래
	S	+	+	.	.	+	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	
Lychnis cognata	H	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	동자꽃
Symplocos chinensis for. *pilosa*	T2	.	.	.	.	.	1.2	1.2	+	3.3	2.3	+	.	+	+	+	+.2	1.1	1.2	.	.	노린재나무
	S	.	1.2	.	.	.	2.3	2.2	3.3	2.2	3.3	.	.	.	.	.	.	.	.	.	.	
Sasa borealis	H	.	.	+	+	.	.	.	+.2	.	5.5	5.5	5.5	5.5	5.5	5.5	4.4	5.5	4.4	5.5	5.5	조릿대
Companions																						
Quercus serrata	T1	.	.	3.3	.	.	.	.	.	.	.	.	.	.	.	+	3.3	3.3	2.2	1.1	+	졸참나무
Quercus serrata	T2	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	
Quercus variabilis	T1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3.3	4.4	굴참나무
Styrox obassia	T1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.1	.	.	.	.	.	쪽동백
	T2	.	.	1.1	.	.	2.2	+.2	.	.	.	+	+	.	.	2.3	.	.	+	.	.	
	S	.	.	+	.	.	+.2	+.2	.	.	.	+	+	.	.	.	.	.	.	.	.	
Lindera obtusiloba	T2	1.2	.	1.1	.	+	+	1.1	+	2.2	.	1.1	1.2	+	.	+	1.1	+	1.2	+	+	생강나무
	S	+	.	+	+	+	+	1.2	+.2	+	+	+	1.2		.	+.2	+	.	.	.	.	
Betula chinensis	T1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	개박달나무
Lespedeza maximowiczii	S	+.2	+.2	.	.	.	1.2	2.2	1.2	3.3	1.1	1.2	+	2.3	1.1	.	+	+.2	+	2.4	.	조록사리
Lespedeza bicolor	S	+	.	.	.	.	+	.	+	.	.	.	.	+	.	.	.	.	.	+	.	싸리
Pteridium aquilinum var. *latiusculum*	H	+	.	.	.	+	+	.	.	.	+	.	+	.	.	.	.	.	.	.	+	고사리
Corylus sieboldiana var. *mand-shurica*	T2	+.2	.	.	+	.	.	+	.	.	.	+	+.2	+	+	.	+.2	+.2	+	.	.	물개암나무
	S	+.2	+	.	+	+	+	+	.	+	.	+	+	.	.	.	+	.	+	.	.	
Syneilesis palmata	H	.	.	.	.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	+	우산나물
Smilax riparia var. *ussuriensis*	H	.	.	.	.	.	.	+	.	.	+	+	.	.	.	.	.	.	.	+	+	밀나물

* A: *Quercus mongolica-Rhododendron schlippenbachii* comm., B: *Q. mongolica-Symplocos chinensis* for. *pilosa* comm., C: *Q. mongolica-Sasa borealis* comm.

Table 2. (Continued)

Community		A					B					C										Common name
Serial number		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Fraxinus rhynchophyiia	T1	.	.	.	.	.	.	.	+	.	.	+	.	.	.	.	+	.	+	.	.	물푸레나무
	T2	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	+	
	S	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	
Ainsliaea acerifolia	H	2.3	1.2	1.1	1.2	2.3	.	2.3	+.2	.	.	+	2.3	.	+	+	.	.	2.2	.	.	단풍취
Maakia amurensis	T1	.	.	.	.	.	+	.	.	.	.	.	+	.	.	+	.	.	+	.	.	다릅나무
	T2	.	.	+	.	.	.	+	.	.	.	+	.	.	.	.	.	+	.	1.1	+	
	S	.	.	.	.	.	+	+	+	.	.	+	.	+	.	.	.	.	.	.	.	
Weigela subsessilis	S	+	.	.	+	+	.	+	1.2	2.2	+	+	.	.	.	.	1.1	1.1	+	.	.	병꽃나무
Codenopsis lanceolata	H	+.2	.	.	.	.	+	+.2	+	.	+	+	+	+	+	.	.	+	.	.	+	더덕
Disporum smlacinum	H	1.2	+	1.2	.	+.2	+.2	.	+.2	.	+.2	+	+	.	.	.	.	.	.	.	+	애기나리
Carex lanceolata	H	1.2	.	.	4.5	3.4	1.2	+.2	1.2	2.2	+.2	.	.	.	.	.	.	.	.	.	.	그늘사초
Carpinus cordata	T1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+.2	.	.	.	까치박달
	T2	.	.	.	2.3	2.2	.	.	+.2	.	.	.	+	.	.	.	.	+	.	.	.	
	S	.	+	.	+	.	+	.	.	.	.	.	.	.	+	.	.	+	.	.	.	
Stephanandra incisa	S	.	.	+	.	.	.	+	+	.	+	.	1.2	.	+	.	+	.	+	.	.	국수나무
Aster scaber	H	.	.	.	+	+	+.2		1.2...	.	.	+	.	.	+	.	.	+	.	.	.	참취
Arisaema angustatum var. *peninsulae*	H	+	+	+	.	.	.	.	.	+	.	.	.	.	+	.	+	.	.	.	.	점박이천남성
Thalictrum punctatum	H	+	.	.	+	+	.	2.3	.	.	.	.	+	.	.	.	.	.	.	.	.	큰잎 산꿩의다리
Artemisia sylvatica	H	.	+	.	+	.	+.2.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	그늘쑥
Rhus trichocarpa	T2	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	개옻나무
Stewartia koreana	T1	.	.	.	.	.	.	+	.	.	.	.	.	.	.	+	.	.	+	.	.	노각나무
	S	.	.	.	.	.	+	+	.	.	.	.	.	.	.	+	.	.	.	.	.	
Salix Koreensis	T2	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	+	.	.	+	버드나무
Vitis amurensis var. *coignetiae*	H	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	머루
Astilbe chinensis	H	+	.	.	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	노루오줌
Schizandra chinensis	H	.	+	.	.	.	.	.	.	+	.	.	.	.	.	.	.	+	.	.	.	오미자
Pyrola japonica	H	.	+	.	.	.	+	.	.	.	.	.	.	.	.	+	.	.	.	.	.	노루발
Carpinus tschonaskii	T2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	개서어나무
	S	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
Polygonatum odoratum var. *pluriflorum*	H	.	.	.	+	.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	둥굴레
Euonymus oxyphyllus	T2	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	참회나무
	S	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	+	.	.	.	.	
Euonymus alatus for. *ciliatodentatus*	T2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	회잎나무
	S	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	

Tilia amurensis(1:T1 - 1.1)(15:T1 - +), *Ligularia fischeri*(2:H - +)(4:H - +), *Osmunda cinnamomea* var. *fokiensis*(4:H - +)(18:H - +), *Kalopanax pictus*(5:T2 - +)(12:T2 - +), *Galium pogonanthum*(6:H - +)(10:H - +), *Cephalanthera falcata*(6:H - +)(20:H - +), *Viscum album* var. *coloratum*(6:H - +)(20:H - +), *Artemisia keiskeana*(6:H - +.2)(17:H - +), *Tilia taquetii*(7:T2 - +)(11:T2 - +), *Viola madshurica*(8:H - +)(18:H - +), *Robdosia japonica*(8:H - +)(18:H - +.2), *Robdosia inflexa*(8:H - +.2)(18:H - +.2), *Asparagus schoberiodes*(8:H - +)(16:H - +), *Diarrhera japonica*(11:H - 1.1)(17:H - +), *Callicarpa japonica*(3:S - +)(18:S - +), *Ulmus davidiana* var. *japonica*(1:H - +), *Thalictrum filamentosum*(2:H - +), *Chrysanthemum zawadskii* var. *latilobum*(6:H - +), *Pimpinella brachycarpa*(4:H - 1.2), *Viola acuminata*(4:H - +), *Hosta longipes*(4:H - +), *Cimicifuga heraccleifolia*(4:H - +), *Adenophora grandiflora*(4:H - 1.2), *Lysimachia barystachys*(4:H - 1.2), *Asarum sieboldii*(5:H - +), *Artemisia japonica*(6:H - +), *Pinus densiflora*(7:T2 - +), *Prunus leveilleana*(7:T2 - +)(7:S - +), *Eeiochloa villosa*(7:H - +), *Rubus crataggifolius*(8:H - +), *Pueraria thunbergiana*(13:H - +), *Lysimachia clethroides*(8:H - +), *Hypericum ascyron*(8:H - +), *Oplismenus undulatifolius*(11:H - +), *Hydrangea serrala* for. *acuminala*(12:S - +), *Galium trachyspermum*(12:H - +), *Aristolochia contorta*(12:H - +), *Smilax nipponica*(13:H - +), *Vitis amurensis*(13:H - +), *Ilex macropoda*(15:H - +), *Betula schmidtii*(16:T1 - +), *Zelkova serrata*(3:T1 - +)(3:S - +), *Sambucus williamsii* var. *coreana*(17:S - +), *Viola orientalis*(20:H - +)

sieboldiana, *Styrax obassia*, *Lindera obtusiloba* and *Acer pseudo-sieboldianum*. The herb layer is composed of *Carex okamotoi*, *Carex siderosticta*, *Melampyrum roseum* and *Ainsliaea acerifolia* mainly. The stems are 13-20cm in DBH with a height of 9~14m. The plant community is composed of an average 25 species per relevé.

(3) *Quercus mongolica-Sasa borealis* community(Table 2-C)

The distribution of this community in Mt. Changan is located from upper slopes to lower slopes between 830m~980m high. This is distinguished from other communities by the presence of *Sasa borealis*, the differential species of Table 2.

Structural characteristics are mixed with *Quercus mongolica*, *Quercus serrata*, *Quercus variabilis* and *Maackia amurensis* in the upper tree layer. The shrub layer is dominated by *Lespedeza maximowiczii* and *Lindera obtusiloba*, and the herb layer is dominated by *Sasa borealis*. The stems of the trees are 12~12cm in DBH with a height of 10~16m. The plant community is composed of an average 21 species per relevé.

2. Ordination analysis

The ordination diagram of CCA shows *Quercus mongolica* forest and environmental variables(Figure 2).

To interpret the CCA axes we used canonical coefficients and the correlation between the environmental variables and the ordination axes. The relative importance of each environmental variable for the prediction axes can be inferred from the signs and relative magnitude of the correlation coefficients(Table 3).

Species score is divided into 3 groups(A, B and C) along the Ⅰ, Ⅱ axes(Figure 2). The arrangement of species among group A was also ecologically meaningful on the *Quercus mongolica* forest. The most important variables among group A is altitude. The species among group A is 5, 7, 8, 10, 11, 13, 20, 26, and 30(Figure 2 legend) and these species are found at higher altitude. Altitude, and topography are the environmental factor determining variation in species score among group A. The species arrangement among group B is 4, 9, 14, 15, 17, 18, 19, 25, 27, 28, 29, 32, 33, 34, 35, 36, and 37(Figure 2 legend).

Table 3. Mt. Changan vegetation data from Figure 2 : canonical coefficients and the inter set correlation of environmental variables with the first two axes of canonical correspondence analysis (CCA)

Axes Variables	Canonical Ⅰ	Coefficients Ⅱ	Correlation Ⅰ	Coefficients Ⅱ
Altitude	0.102	0.507	0.272	0.745**
Moisture	0.925	-0.247	0.817**	-0.126
pH	0.145	-0.332	0.198	-0.622**
Organic matter	0.276	0.204	0.682**	0.320*
C.E.C.	0.050	-0.336	0.520**	0.142
T-N	0.019	0.010	0.373*	0.156
T.G.	0.142	-0.047	-0.487**	0.322*
Slope	0.090	0.103	-0.132	0.048
Eigenvalue	0.994	0.617		

*: $p<0.05$, **: $p<0.01$

Note: C.E.C.: cation exchange capacity, T-N: total nitrogen, T.G.: topography

These species is distributed at higher moisture. Group C is 1, 2, 3, 6, 12, 16, 21, 22, 23, 24, and 38(Figure 2 legend). These species on the *Quercus mongolica* forest are distributed at low actitude, slightly high pH, acidity soil and poor soil.

Figure 3 shows the relationship between the quantitative distribution of *Quercus mongolica* and environmental variables throughout the 40 quadrat in the study area.

Axis Ⅰ of Table 4 shows high correlation between altitude, cation exchange capacity(C.E.C.) and T-N(total nitrogen). Axis Ⅱ shows a high correlation between pH and soil moisture. As in Figure 3 altitude, T-N, C.E.C., and soil organic matter are the importance variables determinig variation in importance valus of *Quercus mongolica*.

Song(1990) distinguished Quercus mongolica group into mesic type, middle type and xeric type, but our result is calculated

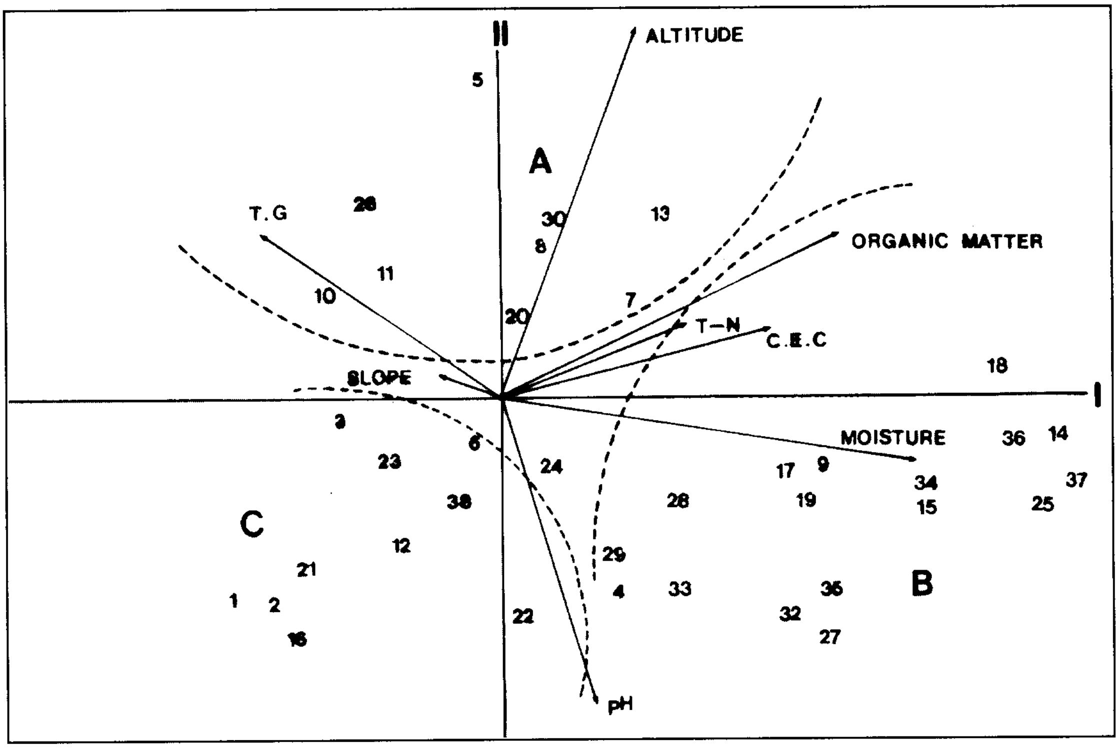

Figure 2. Species score of *Quercus mongolica* in the 40 sites of Mt. Changan: CCA ordination diagram with species and environmental variables(arrow)

(1. Pinus densiflora, 2. Quercus variabilis, 3. Rhus trichocarpa, 4. Quercus serrata, 5. Rhododendron schlippenloachii, 6. Sorbus alnifolia, 7. Acer pseudo-sieboldianum, 8. Prunus sargentii, 9. Actinidia arguta, 10. Rhododendron mucronulatum, 11. Fraxinus sieboldiana, 12. Ilex macropoda, 13. Quercus mongolica, 14. Fraxinus mandshurica, 15. Stewartia koreana, 16. Rhus chinensis, 17. Tripterygium regelii, 18. Acer mono, 19. Cornus controversa, 20. Styrax obassia, 21. Weigela subsessilis, 22. Fraxinus rhynchophylla, 23. Maackia amurensis, 24. Betula costata, 25. Magnolia sieboldii, 26. Betula schmidtii, 27. Carpinus tschonoskii, 28. Ulmus davidiana var. *japonica, 29. Corylus sieboldiana* var. *mandshurica, 30. Symplocos chinensis* for. *pilosa, 31. Deutzia glabrata, 32. Carpinus laxiflora, 33. Betula davurica, 34. Carpiuns cordata, 35. Vitis coignetiae, 36. Philadelphus schrenckii, 37. Lonicera coreana, 38. Euonymus oxyphyllus)*

Table 4. Mt. Changan vegetation data from Figure 3 : canonical coefficients and the inter set correlation of environmental variables with the first two axes of canonical correspondence analysis(CCA)

Variables \ Axes	Canonical I	Coefficients II	Correlation I	Coefficients II
Altitude	-0.053	-0.006	-0.791**	0.174
Slope	0.006	0.001	0.065	0.058
pH	-0.018	-0.006	-0.104	0.604**
Organic matter	0.017	-0.016	-0.192	-0.219
Moisture	-0.031	0.012	-0.231	0.628**
T.G.	-0.033	0.001	0.213	-0.074
C.E.C.	-0.012	-0.007	-0.376*	0.350*
T-N	-0.019	0.010	-0.373*	0.156
Eigenvalue	0.00600	0.00064		

*: p<0.05, **: p<0.01
Note: C.E.C.: cation exchange capacity, T-N: total nitrogen, T.G.: topography

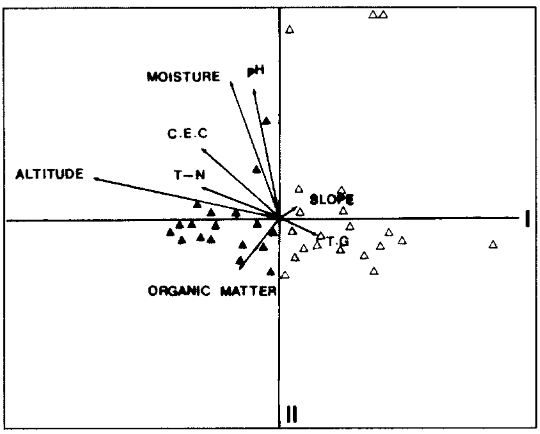

Figure 3. Quantitative distribution of *Quercus monglica* in the 40 sites of Mt. Changansan: CCA ordination diagram with sites and environmental variables(arrow)
Importance value [Xij = (dij + Dij)/2]
(dij : relative density, Dij : relative dominance)
△ : 40 > importance value
▲ : 41 < importance value

to the highest importance values(i.v.) in middle moisture gradient (Kim and Kil, 1997). Thus, the optimal region of this community is considered middle type. Although middle type was the most suitable distribution area, mesic and xeric types were also significant in the distribution of Quercus mongolica(Kim and Kil, 1997). As in data analyzed by CCA, the environmental variables correlated with the species score of Quercus mongolica forest in Mt. Changan are the altitude(CCA: r=0.745), soil moisture(CCA: r=0.817), pH(CCA: r=-0.622), soil organic matter(CCA: r=0.682), C.E.C.(CCA: r=0.520) and topography(CCA: r=-0.487) among various environmental factors.

Altitude and soil moisture were strongly correlated with the dominant compositional gradient at localities examined in this study. This results is a general correspondence with CCA results of near Mt. Tˇogyu(Kim and Kil, 1997). And they are the main factors in determine forest vegetation(Whittaker, 1967; Allen et al., 1991; Song, 1990; Kim and Kil, 1996). The above result is congruent with the data of Song et al.(1987), Kim and Kil(1997), and Kim and Kil(1991).

The ecological meaningful of the study was shown not only classified Quercus mongolica forest in Mt. Changan, but also determined how they were related to one another and to the environmental factors.

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