

Syntaxonomical and Synchorological Characteristics of the Cool-temperate Mixed Forest in the Southern Sikhote Alin, Russian Far East

Kim, Jong-Won and Yuri I. Manyko*

Department of Biology, Keimyong University, Taegu, Korea,

Institute of Biology & Pedology, Far East Branch of Russia,

*Academy of Sciences, Vladivostok, Russia**

극동러시아 남연해주의 냉온대 침활혼합림의 군락분류 및 분포적 특성

김종원 · Yuri I. Manyko*

계명대학교 생물학과, 러시아 과학원 극동지역 생물학 및 토양학 연구소*

ABSTRACT

The northernmost type of the mongolian oak forests in the Russian Far East was studied in terms of syntaxonomy and synchorology. Hand-sorting method, computer program TWINSPAN, CANOCO and SYN-TAX III were engaged for the classification and data analysis. Correlation between plant communities and environmental factors was analyzed by DCA (Detrended Correspondence Analysis) using NeCD (Net Contribution Degree) of species.

Three plant communities were recognized: the *Abieti holophyllae-Quercetum mongolicae*, the *Lespedezo-Quercetum mongolicae* and the *Rosa ussuriensis-Quercus mongolica* community. They were included into the alliance *Jeffersonio-Quercion mongolicae* which is representative to the cool-temperate forests mixed by coniferous and broadleaved trees in southern Sikhote Alin. Human impact was signified as the most important factor to interpret the disjunction of plant communities of which DCA ordination yielded sharp contrasting objects (*i.e.* stands and species).

In the *amphi-Tonghae* region, analogous vegetation types such as the *Jeffersonio-Quercion mongolicae* of Russian Far East, the *Quercion grosseserratae* of Japanese Hokkaido and the *Pino koraiensis-Quercion mongolicae* of Korean Peninsula were reviewed in terms of similarity of species composition and stratum structure. It is signified that the *Jeffersonio-Quercion mongolicae* was one of the continental types more similar to Korean alliance than to Japanese one.

Key words: *Amphi-Tonghae* region, Classification, Lectotype, Net contribution degree, Ordination

INTRODUCTION

The mixed forests composed of *Quercus mongolica*, *Tilia amurensis*, *Tilia mandshurica*, *Acer mono*, *Acer* spp., *Betula dahurica*, *Betula* spp., *Phellodendron amurensis*, *Pinus koraiensis*, *Abies holophylla*, *Abies nephrolepis*, *Fraxinus rhynchophylla*, *Kalopanax pictus* and so on, are the extensive vegetation type in the South Sikhote Alin (Berg 1959, Kolesnikov 1956, 1961, Kurentsova *et al.* 1968, Tseplyaev 1965), southern Manchuria of Northeast China (Chou *et al.* 1990, Hou 1983) and northern Korean Peninsula (Kim 1990, Lee and Lee 1986) in the Northeast Asia. Mixed forests composed of *Quercus mongolica* var. *grosseserrata* and *Abies sachalinensis* are found in Hokkaido (Kim 1989b, Miyawaki 1988, Takeda *et al.* 1983), and this primitive forest aggregation is called as "Pan-Mixed Forests" (Tatewaki 1955).

Syntaxonomical (*sensu* Zürich-Montpellier school) study in the Russian Far East has been once carried out up-to-date by Galkina and Petelin (1990), if many in the other areas (see Korotkov *et al.* 1991). Classification of these mixed forests was made mainly by phytocoenotic study (Solov'ev 1958); so called genetic classifications were worked out exactly in these forests (Kolesnikov 1956, Smagin 1965, Sochava 1944, 1946), and methods by the Alekseev-Pogrebnyak's school were tested as well (Solodukhin 1965).

The aims of current study are to identify and characterize the syntaxa syntaxonomically and synchronologically about the mixed forests of the South Sikhote Alin. The consecutive accessible hierarchical system about these mixed forests was developed, even though the number of relevé obtained is not many. Furthermore, a synthesized table was compared with vicarious phytocoenose in surrounding areas. In so doing a few data published previously were treated by using several computer programs. Especially various packages developed for numerical syntaxonomy are useful for accomplishing objectively comparative studies about forest vegetation in which a greater number of species occur (Mucina and van der Maarel 1990) and for correlation of identified-syntaxa to their ecology (*e.g.* Hukusima and Kershaw 1988). The results of present study might be endorsed by syngéographical and syntaxonomical informations on the regional forest types (Kim 1989a).

STUDY AREA

The phytosociological survey was carried out in the south Primorye, mainly in the Ussuriysk Reserve Territory and in the surroundings of Vladivostok (Fig. 1). The areas have the relief with low mountains not higher than 300~500 m above sea level. There are agricultural fields in the flat territories adjacent to the spurs of the mountains and in the river valleys where only remnants of the natural woods dominated by *Quercus mongolica* occur. However, the forests of the Ussuriysk Reserve (40,432 ha), made on V. L. Komarov's initiative in 1932, are still rich and conserved their natural composition. Principal distri-

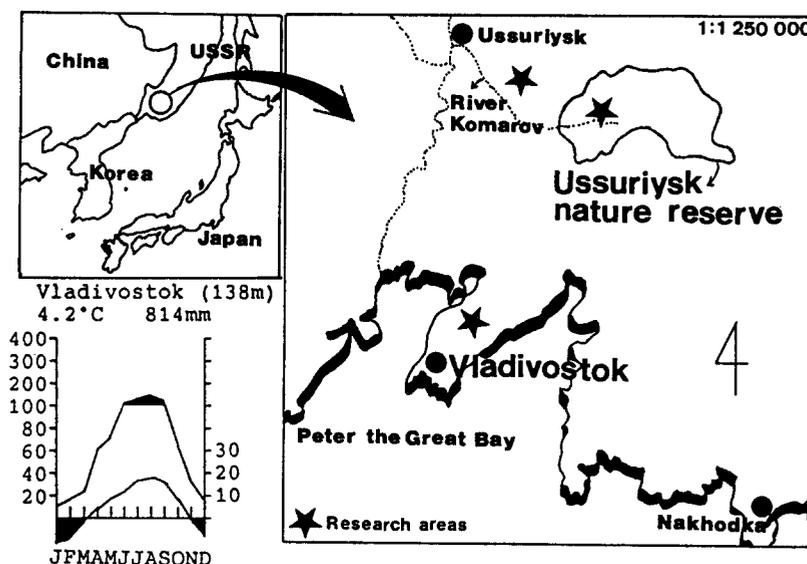


Fig. 1. Geography and climate of investigated areas.

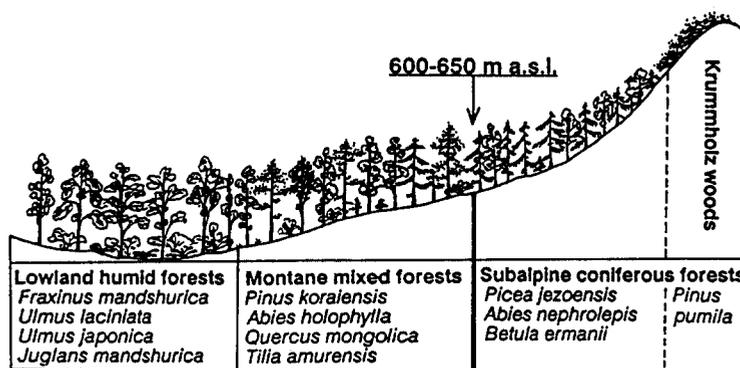


Fig. 2. General scheme of distribution pattern of forest vegetation in the southern Primorye region.

tribution scheme of the vegetation is shown in Fig. 2. Around 600 m in altitude the cool-temperate forests change gradually into the subalpine coniferous forests. Present study was mainly conducted below 500 m a.s.l.

The climate is characterized by monsoons with very cold-dry continental airmass in winter (like harsh Manchuria climate) and very warm-humid maritime airmass in summer. The high sea humidity in July-August is nearly 90 % in average (cf. 78 % in Seoul). Annual mean temperature and annual precipitation are 4.2 °C and 814 mm at the Meteorological Station of Vladivostok (138 m a.s.l., 43°07'N, 131°54'E), respectively (Fig. 1; Tokyo Astronomical Observatory 1988, statistics during 1951-1980). In the Ussuriysk Reserve they are 2.5 °C and 750-800 mm, respectively (Kharkevich 1978). The soils are formed on basalt and shale in many cases, and locally on small granites.

MATERIALS AND METHODS

After preliminary reconnaissance like representativeness and homogeneity in the study areas, the relevés were subjectively randomly taken according to the Braun-Blanquet approach (Braun-Blanquet 1964) in 1990 (Table 1). They were sophisticatedly sorted by hand. In order to extract the syntaxonomical units (*sensu* Zürich-Montpellier school), their final arrangement was supported by the outcome of numerical treatment by TWINSpan (Hill 1979) and SYN-TAX III (Podani 1988). The species were ordered according to their diagnostic value (Westhoff and van der Maarel 1973). A species was regarded as diagnostic when it was restricted to syntaxa known from the surrounding areas such as Northeast China (Kim 1992), Korean Peninsula (Kim 1990, Song 1988) and Hokkaido (Miyawaki 1988).

In community tables (species x relevé) obtained by classification, Braun-Blanquet scale (r - 5) of species was transformed into a combined scale (1 - 9; van der Maarel 1979) for numerical analysis by the program CANOCO (Ter Braak 1988). A condensed table of environmental data was prepared by comprising the nominal environmental variables: slope direction, surface soil texture, topography, micro-topography and a kind of human impacts (Table 2). Although human impacts can be regarded as somewhat ordinal scale indicating the intensity of factors, but in fact, their qualitative property does possess an independent order which is unrelated to each other. All environmental variables involved are regarded as a fundamental site descriptor affecting plant growth and performance in the phytocoenose. Altitudinal condition was also considered, even though altitudinal oscillation of relevés is unremarkable by locating below 300 m a.s.l. Two sets of data matrix (species x relevé and environmental variables x relevé) were ordinated by detrended correspondence analysis (DCA; Hill and Gauch 1980), which is an improved method from the correspondence analysis (CA) having an arch effect (Jongman *et al.* 1987). A scatter diagram of relevés was presented for understanding ecological relationships between plant communities and environmental factors.

To manifest similarity between vicarious types of syntaxa, present data and previously published ones (*e.g.* Kim 1990, Suzuki 1988) were synthesized. This synthesized table was summarized from 14 plant communities which are consisted of 232 relevés and 852 species in three alliances (Table 3). The *Rhododendron kaempferi-Quercus mongolica* var. *grosseserrata* community has been included into the Carpino-Quercion serratae Miyawaki *et al.* 1971 (Suzuki 1988). However, that could be subjectively dealt with a member of Quercion grosseserratae Tohyama *et* Mochida 1978 (*cf.* Carpino-Quercion grosseserratae Takeda *et al.* 1981 as a synonym according to Art 19 and 31 of the Nomenclature Code) comprising Hokkaido elements such as *Acer mono* var. *glabrum* and *Angelica ursina*.

In order to compare vicarious alliances, the synoptic values of species such as general constancy degree and specific synoptic value (van der Maarel *et al.* 1985) are used. The

Table 1 Site and stand characteristics for relevés investigated. Running numbers are coincided with those of Tables 4, 5 and 6.

A	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	
B	2	28	29	30	1	4	22	23	24	25	26	27	11	13	16	19	20	5	6	7	18	8	10	9	12	14	17	3	15	21	
C	110	200	215	240	105	75	250	210	250	205	220	240	200	265	275	190	200	60	65	75	145	85	95	90	230	145	270	130	95	250	
D	N	N	N	N	NE	N	-	-	S	S	S	W	N	N	NE	S	SW	N	N	N	N	SE	N	N	S	S	S	S	S	S	
E	0	15	25	15	5	10	0	0	20	20	5	5	10	12	15	5	10	2	3	3	0	5	10	3	10	10	10	25	30	20	
F	500	750	900	240	500	500	900	500	750	500	500	100	375	625	500	625	500	500	400	500	500	500	400	500	500	375	625	300	500	450	
G	23	40	24	34	22	23	16	30	29	28	24	23	20	20	21	20	22	16	18	20	19	20	16	17	18	17	15	13	14	14	
H	90	60	90	90	85	85	85	80	80	70	85	85	95	90	85	80	85	90	90	90	85	90	80	85	85	90	80	60	95	70	
I	15	8	10	13	9	14	9	12	11	10	9	11	10	10	11	10	12	8	9	8	10	10	8	12	8	10	9	7	9	8	
J	40	65	60	40	70	40	40	50	10	15	10	5	5	40	20	15	10	20	50	45	10	20	20	40	10	5	5	10	5	20	
K	3	3	2.5	3	3	3	2.5	4	4.5	4	3.5	2.5	3.5	3.5	3	2.5	3.5	4	3	5	3.5	3	3.5	2.5	2.5	2.5	2.5	2.5	3	2.5	
L	70	40	40	60	80	60	50	60	40	60	50	60	70	65	50	50	75	50	60	60	60	65	50	50	80	40	70	80	60	70	
M	0.8	1.5	0.5	0.5	0.5	1	0.8	1	1	0.8	0.8	0.8	1	1	1	1.5	1	1	1.5	1	1	1	1	1	1	1	0.8	0.8	1	0.8	0.8
N	90	90	60	60	80	80	85	90	80	50	50	85	80	90	95	90	70	85	85	90	80	95	95	95	80	85	75	95	80	80	
O	60	58	55	52	54	51	77	73	81	48	44	39	52	59	54	57	53	60	59	69	57	76	72	73	62	49	39	52	58	46	
P	1	1	1	1	1	1	9	9	5	5	5	7	1	1	2	5	6	1	1	1	1	5	4	1	1	5	5	5	5	5	
Q	2	3	3	3	3	3	2	2	2	4	4	4	3	3	2	3	2	4	3	3	3	3	3	3	2	3	2	2	2	1	
R	3	4	3	1	3	3	3	3	3	2	2	1	4	3	4	4	4	3	3	3	3	3	3	3	4	3	3	1	3	1	
S	3	2	2	3	2	3	3	2	1	2	4	4	2	4	4	3	3	3	3	3	3	3	4	3	3	4	2	3	2	2	1
T	3	1	1	1	3	4	3	2	1	1	1	1	3	3	3	3	2	3	4	4	4	3	4	3	4	3	4	5	5	3	

Notes: A - Running no. ; B - Relevé no. ; C - Altitude (m); D - Slope; E-Inclination (°); F - Area (m²); G to N - Height (m) & coverage (%) of Tree 1, 2, Shrub- & Herb-layer, respectively ; O - Occurrence number of species; Environmental variables P, Q, R, S & T: Slope direction, Substrate, Topography, Micro-topography & Human impacts, respectively.

Table 2. Environmental variables used in numerical analysis.

		Nominal environmental variables			
A	SLDI	SFST	TOPO	MITO	HUIM
1	North	Exposed stone	Ridges	Spur	Almost none
2	NE	-	Upper slopes	-	-
3	East	A little exposed	Mid slopes	Flat	Weak
4	SE	-	Lower slopes	-	-
5	South	None	Valley	Sinkage	Strong
6	SW	Notes: A - Categories; SLDI - Slope direction; SFST - Surface soil texture with substrate material of granitic and /or basaltic stone ; TOPO - Topography; MITO - Micro topography ; HUIM - Human impacts (excluding wild animal activities ; Week = collecting edible plants & hunting animal to disturb the herb-layer; Strong = cutting woods, recent and frequent fire to disturb the shrub-layer)			
7	West				
8	NW				
9	L				

Table 3. Summary of materials used in the synthesized table. They are composed of 232 relevés and 852 species.

Abbreviation of syntaxa	No. relevés	No. Spp.	Sources
Quercion grosseserratae (Hokkaido, Japan)	147	482	Miyawaki ed.
CAR-QUE Carpino-Quercetum grosseserratae*	61	343	(1988)
SKI-QUE Skimmio-Quercetum grosseserratae	27	179	
ABI-QUE Abieti sachalinensis-Quercetum grosseserratae	25	185	
OST-QUE Ostryo-Quercetum grosseserratae	9	167	
DRY-ABI Dryopterido-Abietetum myrianae	12	150	
MEN-QUE <i>Menziesia pentandra-Quercus grosseserrata</i> comm.	4	42	
BET-QUE <i>Betula lauschii-Quercus grosseserrata</i> comm.	5	58	
RHO-QUE <i>Rhododendron kaempferi-Quercus grosseserrata</i> comm.	4	83	
Pino koraiensis-Quercion mongolicae (Korean Peninsula)	55	351	Kim
LYC-QUE Lychno-Quercetum mongolicae	12	196	(1990)
VAC-QUE Vaccinio-Quercetum mongolicae	25	201	
DRY-QUE Dryopterido-Quercetum mongolicae	18	234	
Jeffersonio-Quercion mongolicae (Southern Primorye)	30	268	Kim
ABI-MON Abieti holophyllae-Quercetum mongolicae	12	174	(1992)
LES-QUE Lespedezo-Quercetum mongolicae	17	216	
ROS-MON <i>Rosa ussuriensis-Quercus mongolica</i> comm.	1	46	

* The materials of Carpino-Quercetum grosseserratae were from Miyawaki ed. (1989) and Toyama and Mochida (1978).

later comprises the degree of species performance combining both coverage (C_i) and frequency (n/N) in the identified unit (cf. Miyawaki and Kim 1985). This synoptic value will be here called 'Net Contribution Degree (NeCD)' to distinguish it from other ones. In preliminary test of several kinds of synoptic values (*e.g.* Malmer's characteristic degree, total coverage, mean coverage, mean frequency, percent frequency, a kind of variance and entropy) for a syntaxonomical unit, NeCD was signified the most conventional synoptic value for comparative study (Kim *et al.*, unpublished). The NeCD can be determined by the following function:

$$\text{NeCD} = \sum C_i / N \times n / N \quad (C_{\min} \leq \text{NeCD} \leq C_{\max}) \quad \text{-----} \quad (1)$$

where $\sum C_i$ is the sum of coverage of species i in the unit, n is the number of relevé possessing species i and N is the total number of relevé in the unit. This NeCD is an absolute value to the unit, which becomes smaller value when the relevé number being involved in the unit increases. Therefore, in order to compare objectively two units described by different relevé numbers, relative value of NeCD (R-NeCD) to each unit was calculated as:

$$\text{R-NeCD} = \text{NeCD}_i / \text{NeCD}_{\max} \times 100 \quad \text{-----} \quad (2)$$

where NeCD_i and NeCD_{\max} are NeCD value of species i and maximum NeCD value of certain species in a unit, respectively. This R-NeCD of species to the unit might be a sophisticated descriptive value differing from the constancy degree (I, II, III, IV and V) which is highly sensitive to relevé numbers being arranged for the unit. The NeCD value was computed by program SYNOPT1 (Hauser, unpublished).

The program NCLASa and PRINCOOR in the SYN-TAX III was subjected to dissimilarity ratio and complete-average linkage algorithm for clustering and ordinating 14 plant communities. The clustering method was also applied to the relevé grouping in the Jeffersonio-Quercion mongolicae. This classification algorithm is known as less sensitive for data transformation (Wildi 1980).

Nomenclatural solution was simultaneously referred by the following literatures: Lee (1979), Ohwi (1978), Voroshilov (1982) and Academia Sinica (1985) for idiotaxa, and Barkman *et al.* (1986) for syntaxa.

RESULTS AND DISCUSSIONS

(1) Syntaxa

Abieti holophyllae-Quercetum mongolicae Kim J.W. 1992

The Abieti holophyllae-Quercetum mongolicae represents the mixed coniferous-broadleaf forest type of the Sikhote Alin region. This association can be considered the

potential natural vegetation from its natural situation. The stands were found today in the Ussuriysk Reserve.

Species composition was comparatively rich (57.7 spp./relevé) and the canopy layer was well developed up to 40 m in height, which is dominated by *Pinus koraiensis* and *Quercus mongolica* in halves approximately (Kudinov 1989). *Quercus mongolica*, *Pinus koraiensis*, *Syringa amurensis*, *Carex ussuriensis*, *Lonicera praeflorens*, *Carpinus cordata*, *Acanthopanax senticosus*, *Acer barbinerve* and *Acer tegmentosum* characterize this association as one of the typical northernmost cool-temperate mixed forests in Northeast Asia. Most diagnostic species are regional character species which are distributed widely but characterize provincial areas. Species contributing highly to the establishment of the association are as follows (ranking on the NeCD): *Quercus mongolica*, *Pinus koraiensis*, *Abies holophylla*, *Acer pseudosieboldianum*, *Syringa amurensis*, *Carpinus cordata*, *Thalictrum filamentosum*, *Acer mono*, *Carex ussuriensis*, *Carex drymophila* s. l.

Similar physiognomy is also found in Hokkaido, Japan (Kim 1989b, Miyawaki 1988) and Manchurian territory (Chou *et al.* 1990, Kim 1992). The Abieti sachalinensis-Quercetum grosseserratae Suzuki S. in Miyawaki *ex hoc loco* (lectotype: No. 32, Table 14 of Suzuki S. in Miyawaki, 1988) of Hokkaido and the Lychno-Quercetum mongolicae Kim J.W. 1990 of the Korean Peninsula (Lee *et al.* 1994) are geographical races of this association.

The intra-associations were clearly differentiated according to species composition and site condition. It was best classified into four subassociations, *i.e.* the subass. ulmetosum laciniatae, circaeetosum alpinae (lectotype: No. 3 in Table 4), athyrietosum pycnosorum (lectotype: No. 7 in Table 4) and iricetosum uniflorae (lectotype: No. 12 in Table 4).

Lespedezo-Quercetum mongolicae Kim J.W. 1992

The association Lespedezo-Quercetum mongolicae is typical as a secondary forest type of the Abieti hollophyllae-Quercetum mongolicae, which has been recently suffered from human activities such as fire, cutting chops and gathering edible plants near Kamenusca village. Character and differential species are *Lespedeza bicolor*, *Corylus heterophylla*, *Vicia unijuga*, *Convallaria keiskei*, *Geranium eriostemon*, *Carex lanceolata*, *Artemisia sylvatica* and *Isodon exisus*. Especially *Lespedeza bicolor* (Leguminosae) and *Corylus heterophylla* are considered transgressive-character species (*sensu* Mucina, unpubl.) to fire disturbance. In the plant communities, occurrence and redundancy of conifers such as *Pinus koraiensis* and *Abies holophylla* were reduced while *Quercus mongolica* dominates in the canopy-layer. Species ranking on the contribution to the association differs from above natural association, *i.e.* *Quercus mongolica*, *Carex lanceolata*, *Acer mono*, *Tilia amurensis*, *Fraxinus rhynchophylla*, *Lespedeza bicolor*, *Corylus heterophylla*, *Convallaria keiskei*, *Jeffersonia dubia*, *Corylus sieboldii* var. *mandshurica*. Such syndynamical facts were well proved by Kudinov (1989) and Yang and Wu (1987).

The stands were found more frequently and abundantly at south-facing slopes than north-facing slopes and near the inhabited lands in the southern Primorye region. Range

Table 4. Structured vegetation table of the *Abieti holophyllae-Quercetum mongolicae*.

UL : ulmetosum laciniatae CA : circaeetosum alpinae
 AP : athyrietosum pycnosorum IU : iricetosum uniflorae

Unit:	UL	CA	AP	IU	Synoptic values	
	Running No. :				CD	NeCD
	0	000	00000	111		
	1	234	56789	012		
<u>Abieti holophyllae-Quercetum mongolicae</u>						
<i>Pinus koraiensis</i> S. et Z.	Ch :	1 343	++212	323	V	5.083
<i>Syringa amurensis</i> Rupr.	Ch :	1 +++	+2++2	+12	V	2.916
<i>Carpinus cordata</i> Bl.	Ch :	2 221	4+121	+. .	V	2.847
<i>Carex ussuriensis</i> Kom.	Ch :	. 223	+. +1	+++	V	2.222
<i>Acer barbinerve</i> Max.	Ch :	2 2++	++111	+. .	V	2.013
<i>Lonicera praeflorens</i> Batal.	Ch :	. 1++	+. .+	++1	IV	1.250
<i>Acanthopanax senticosus</i> (R. et M.) H.	Ch :	+ +++	..+1.	+. +	IV	0.944
<i>Acer tegmentosum</i> Max.	Ch :	+ +++	+1.1.	... III	III	0.777
<i>Abies holophylla</i> Max.	D :	. 232	23121	+1+	V	3.590
<i>Maianthemum bifolium</i> (L.) F. W. Schm.	D :	1 +++	1++2+	+. .	V	1.736
<i>Oxalis acetosella</i> L.	D :	2 111	+. +2+	..+ IV	IV	1.687
<u>ulmetosum laciniatae</u>						
<i>Phellodendron amurense</i> Rupr.	D :	1 ...	..1..	... I	I	0.083
<i>Fraxinus mandshurica</i> Rupr.	D :	1 ...	....+	... I	I	0.069
<i>Prunus padus</i> L. s.l.	D :	+ ...	..1..	... I	I	0.069
<i>Alnus hirsuta</i> (Spach) Rupr.	D :	2 ...	.....	... I	I	0.034
<i>Ulmus laciniata</i> (Trautv.) Mayr	D :	1 ...	.....	... I	I	0.020
<i>Caulophyllum robustum</i> Max.	D :	+ ...	.....	... I	I	0.013
<i>Cimicifuga dahurica</i> Max.	D :	+ ...	.....	... I	I	0.013
<u>circaeetosum alpinae</u>						
<i>Diarrhena mandshurica</i> Max.	D :	. 1++	....+	1.. III	III	0.416
<i>Ribes mandshuricum</i> Kom.	D :	+ +++	+. . .	... III	III	0.347
<i>Spiraea ussuriensis</i> Pojark	D :	1 +++	.....	... II	II	0.250
<i>Circaea alpina</i> L.	D :	. 1+2	.....	... II	II	0.208
<i>Acer mandshuricum</i> Max.	D :	. 1++	.....	... II	II	0.145
<u>athyrietosum pycnosorum</u>						
<i>Pyrola japonica</i> Klentze	D :	. ...	+++++	..+ III	III	0.500
<i>Athyrium pycnosorum</i> H. Christ	D :	. +..	+++.	... III	III	0.347
<i>Prunus maximowiczii</i> Rupr.	D :	. 1..	..+1.	... II	II	0.277
<i>Polemonium racemosum</i> (Regel) Kitamura	D :	. ...	+++++	... II	II	0.222
<i>Athyrium spinulosum</i> (Max.) Milde	D :	. ...	+++.	... II	II	0.222
<i>Lathyrus komarovii</i> Ohwi	D :	. ...	..+++	+. II	II	0.222
<i>Artemisia sylvatica</i> Max.	D :	. ...	+++.	... II	II	0.125
<i>Campanula punctata</i> Lam.	D :	. ...	+++.	... II	II	0.125
<i>Circaea cordata</i> Royle	D :	. ...	..+1	... I	I	0.069
<i>Osmundastrum cinna. v. fokiense</i> (C.) T.	D :	. ...	+1..	... I	I	0.069
<u>iricetosum uniflorae</u>						
<i>Aralia elata</i> Seem.	D :	. ...	....1	+++ II	II	0.250
<i>Iris uniflora</i> Pall. ex Link	D :	. ...	.....	+++ II	II	0.125

Table 4. Continued.

<i>Viola orientalis</i> W. Becker	D : +.+	I 0.055
<i>Bupleurum longiradiatum</i> Turcz.	D : +.+	I 0.055
<i>Fragaria orientalis</i> Losinsk.	D : +.+	I 0.055

Jeffersonio-Quercion mongolicae

<i>Carex drymophila</i> v. <i>abbreviata</i> (Kü.) Oh.	Ch : + 1++ ++3+1 .++	V 2.215
<i>Convallaria keiskei</i> Miq.	Ch : . +++ 1++++ +++	V 1.756
<i>Euonymus pauciflorus</i> Max.	Ch : + .++ 1++++ .++	V 1.458
<i>Jeffersonia dubia</i> Benth.	Ch : . .1+ +++++ ++.	IV 1.187
<i>Carex pediformis</i> v. <i>reventa</i> (V. Kre.) W.	Ch : ++.+. 333	III 1.125
<i>Actinidia kolomikta</i> (M. et R.) Max.	Ch : 1 +++ ++1. . . .	IV 1.000
<i>Betula dahurica</i> Pall.	Ch : . 11. 1112. . . .	III 0.833
<i>Cardamine leucantha</i> O. E. Schulz	Ch : . ++. . . . + +.	III 0.500

Rhododendro-Quercetalia mongolicae

<i>Quercus mongolica</i> Fisch.	Ch : 2 111 55433 232	V 5.916
<i>Acer pseudosieboldianum</i> (Pax.) Kom.	Ch : 1 +1+ 3+2.2 141	V 3.284
<i>Tilia amurensis</i> Rupr.	Ch : + +11 2+. ++ +1+	V 2.138
<i>Corylus sieb.</i> v. <i>mandshurica</i> (M.)C.K.S.	Ch : . ++. +++++ +++	V 1.388
<i>Fraxinus rhynchophylla</i> Hance	Ch : . +. 1+1++ ++.	IV 1.000
<i>Maackia amurensis</i> Rupr. et Max.	Ch : . +++ ..+. + +++	IV 0.888

Notes: Ch - character soecies; D - differential species. CD - Constancy degree, NeCD - Net contribution degree. (Companions are omitted. Refer complete vegetation data in the table 10 of Kim 1992.)

Table 5. Structured vegetation table of the *Lespedeza-Quercetum mongolicae*.

SR : *saniculetosum rubriflorae* HA : *hypericetosum ascyron*
CP : *crataegetosum pinnatifidae*

Unit:

Running No. :

SR	HA	CP	Synoptic values	
11111	1122222222	22	CD	NeCD
34567	8901234567	89		

Lespedeza-Quercetum mongolicae

<i>Carex lanceolata</i> A. Gray	Ch: .+. + 22+2212135 1+	V 2.809
<i>Lespedeza bicolor</i> Turcz.	Ch: .+. + 1+++++1+4 31	V 2.034
<i>Corylus heterophylla</i> Fish. Bl.	Ch: +. . . + +++2+1+31+ 1+	V 1.889
<i>Convallaria keiskei</i> Miq.	Ch: ++. ++ 11++11++++ ..	V 1.550
<i>Artemisia sylvatica</i> Max.	Ch: + 111. +. 112+ 2+	IV 1.453
<i>Vicia unijuga</i> A. Br.	Ch: .+. ++ .+. +1++++ 21	IV 1.204
<i>Isodon excisus</i> (Max.) Kudo	Ch: ++2+. ++++++. . .	IV 1.121
<i>Geranium eriostemon</i> Fisch.	Ch: +. . . + .++++. ++ +.	IV 0.837
<i>Chloranthus japonica</i> Sieb.	D: +1+1 1+ . +	III 0.653
<i>Artemisia keiskeana</i> Miq.	D: 1. +. +. 2+	II 0.242

saniculetosum rubriflorae

<i>Dryopteris crassirhizoma</i> Nakai	D: .+3+. . . . +.	II 0.179
<i>Sanicula rubriflora</i> Fr. Schm.	D: +++++	II 0.173

Table 5. Continued.

<i>Polemonium racemosum</i> (Regel) Kitamura	D: .+++ 1	II	0.124
<i>Cypripedium calceolus</i> L.	D: .++ . + +	II	0.110
<i>Pyrola japonica</i> Klenze	D: .+ . ++ +	II	0.110
<i>Adiantum pedatum</i> L.	D: +++	I	0.062
<i>Paris verticillata</i> M. v. Bieb.	D: +++	I	0.062
<u>hypericetosum ascyron</u>			
<i>Adenophora triphylla</i> v. <i>hirsuta</i> Nakai	D: + + + + + + +	III	0.442
<i>Vicia venosa</i> v. <i>baicalensis</i> (T.) Worosch	D: + + + + + +	III	0.339
<i>Potentilla fragaroides</i> L.	D: + . + . + + + +	III	0.339
<i>Potentilla fragaroides</i> v. <i>major</i> Max.	D: + + . . 1 + + +	II	0.269
<i>Codonopsis lanceolata</i> (S. et Z.) Trautv.	D: + 1 + . + + . +	II	0.269
<i>Galium spurium</i> L.	D: + . . . 1 2 + . 1	II	0.259
<i>Hypericum ascyron</i> L.	D: + + . . . + + . + +	II	0.249
<i>Viola collina</i> Hemsf.	D: + . + . . + + + . +	II	0.249
<i>Dictamnus dasycarpus</i> Turcz.	D: + . 1 . . . 1 . +	II	0.207
<u>Variant Anemone udensis</u>			
<i>Betula platyphylla</i> v. <i>japonica</i> Hara	D: + 1 2 1 1 + 2 2 1	III	0.965
<i>Filipendula palmata</i> (Pall.) Maxim.	D: . . . + . + + + + 1 + +	III	0.591
<i>Angelica sachalinensis</i> Maxim.	D: . . . + + + + + + . +	III	0.560
<i>Anemone udensis</i> Trautv. et Mey.	D: + + + + +	II	0.249
<i>Muhlenbergia japonica</i> Steud.	D: + + + . 2	II	0.152
<i>Bupleurum longiradiatum</i> Turcz.	D: + + + +	II	0.110
<i>Diarrhena mandshurica</i> Max.	D: 1 1 1	I	0.093
<u>crataegetosum pinnatifidae</u>			
<i>Peucedanum terebinthaceum</i> Fisch.	D: + 1 +	I	0.072
<i>Crataegus pinnatifida</i> Bunge	D: + 1	I	0.034
<i>Artemisia gmelinii</i> Web. ex Stechm.	D: + +	I	0.027
<i>Acer barbinerve</i> Max.	D: + +	I	0.027
<u>Jeffersonio-Quercion mongolicae</u>			
<i>Jeffersonia dubia</i> Benth.	Ch: + 1 1 + + 1 1 . . + . +	IV	1.529
<i>Betula dahurica</i> Pall.	Ch: . 1 1 . 1 1 2 1 1 . 1 . 1 . 1 . 1	IV	1.332
<i>Carex drymophila</i> v. <i>abbreviata</i> (Kü.) Oh.	Ch: . 3 1 1 + 2 1 + 1 + +	IV	1.294
<i>Cardamine leucantha</i> O. E. Schulz	Ch: 1 + 1 + + + . + + +	III	0.622
<i>Carex pediformis</i> v. <i>reventa</i> (V. Kre.) W.	Ch: + 1 + + + . 1 +	III	0.387
<i>Euonymus pauciflorus</i> Max.	Ch: + 1 + + + . 1 +	III	0.387
<i>Actinidia kolomikta</i> (M. et R.) Max.	Ch: 1 . + . 1 . + + . +	II	0.290
<u>Rhododendro-Quercetalia mongolicae</u>			
<i>Quercus mongolica</i> Fisch.	Ch: 35533 5555545554 25 V	8.294	
<i>Tilia amurensis</i> Rupr.	Ch: + 1 1 1 2 1 2 + + 1 1 1 1 1 1 V	2.657	
<i>Fraxinus rhynchophylla</i> Hance	Ch: + 1 + + . 1 1 + + 2 + + 1 1 + 2 + V	2.380	
<i>Corylus sieb. v. mandshurica</i> (M.) C.K.S.	Ch: 1 + 2 1 + 1 + + + + 1 . + IV	1.484	
<i>Maackia amurensis</i> Rupr. et Max.	Ch: + 1 1 1 . + + + 1 + 1 1 + IV	1.245	
<i>Acer pseudosieboldianum</i> (Pax.) Kom.	Ch: . + + . . 1 2 + + + 2 + + III	0.934	

Notes: Ch - character species; D - differential species. CD - Constancy degree, NeCD - Net contribution degree. (Companions are omitted. Refer complete vegetation data in the table 10 of Kim 1992)

of ecological distribution covers very diverse topographic and edaphic conditions. Geographically, vicarious forests were observed at central region (e.g. Mt. Maoershan) in the Northeast China, in which a fagot of *Lespedeza bicolor* shrubs is much more abundant than *Spiraea ussuriensis* (Kim 1992).

The association can be further described by the subass. saniculetosum rubriflorae (lectotype: No. 17 in Table 5), hypericetosum ascyron (lectotype: No. 26 in Table 5) and crataegetosum pinnatifidae (lectotype: No. 29 in Table 5). These subassociations are growing along the moisture gradient of sites.

***Rosa ussuriensis-Quercus mongolica* community**

The *Rosa ussuriensis-Quercus mongolica* community (Table 6) was very rarely found in the spur parts of mountain where substrate is very dry and granitic rocky soils. A couple of differential species such as *Rhododendron mucronulatum*, *Rosa ussuriensis* (subdominant species in shrub-layer), *Iris uniflora* and *Gymnocarpium dryopteris*, are closely restricted to

Table 6. The *Rosa ussuriensis-Quercus mongolica* community. (Running No. 30 in Table 1)

Differential spp. of community:			
<i>Rosa ussuriensis</i>	2	<i>Iris uniflora</i>	+
<i>Rhododendron mucronulatum</i>	4	<i>Gymnocarpium dryopteris</i>	+
<i>Lespedeza bicolor</i>	1	<i>Dictamnus dasycarpus</i>	1
<i>Viola orientalis</i>	+	<i>Carex lanceolata</i>	1
Character spp. of Jeffersonio-Quercion mongolicae:			
<i>Betula dahurica</i>	1	<i>Carex pediformis</i> v. <i>reventa</i>	+
<i>Pinus koraiensis</i>	+	<i>Carex drymophila</i> v. <i>abbreviata</i>	2
<i>Euonymus pauciflorus</i>	+		
Character spp. of Rhododendro-Quercetalia mongolicae			
<i>Quercus mongolica</i>	3	<i>Tilia amurensis</i>	+
<i>Pyrola japonica</i>	+	<i>Corylus sieb.</i> v. <i>mandshurica</i>	+
<i>Acer mono</i>	1		
Companions:			
<i>Waldsteinia ternata</i>	+	<i>Cimicifuga dahurica</i>	+
<i>Tulotis asiatica</i>	+	<i>Artemisia keiskeana</i>	1
<i>Schizandra chinensis</i>	+	<i>Peucedanum terebinthaceum</i>	+
<i>Muhlenbergia japonica</i>	+	<i>Potentilla fragaroides</i>	+
<i>Ulmus davidiana</i> v. <i>japonica</i>	+	<i>Aster scaber</i>	+
<i>Viola acuminata</i>	+	<i>Fragaria orientalis</i>	+
<i>Tilia mandshurica</i>	+	<i>Atractylodes japonica</i>	+
<i>Sanguisorba officinalis</i>	+	<i>Vicia amurensis</i>	+
<i>Melampyrum roseum</i>	+	<i>Arundinella hirta</i>	2
<i>Potentilla fragaroides</i> v. <i>major</i>	+	<i>Caragana fruticosa</i>	+
<i>Lysimachia vul.</i> v. <i>dahurica</i>	+	<i>Carex sp.</i> -I	+
<i>Rubia chinensis</i>	+	<i>Veratrum maackii</i> s. <i>l.</i>	+
<i>Synurus deltoides</i>	+	<i>Betula platyphylla</i> v. <i>japonica</i>	+
<i>Calamagrostis sp.</i> -I	+	<i>Galium spurium</i>	+

such peculiar edaphic and topographic habitats. The shrub-layer is dominated by *Rhododendron mucronulatum* whose northern limit of distribution might be this region. This species dominates widely in the secondary oak forests throughout the Korean Peninsula (Dostalek *et al.* 1988, Jeong 1992, Kim 1990, 1992) but disappears completely in the Northeast China (Kim 1992). *Rosa ussuriensis* included into Sect. Cinnamomeae is still left as a taxonomical problem, because local taxonomists identified it as *Rosa pimpinellifolia* which occurs in Europe ($2n=28$) and in Asia ($2n=14$) according to Hea *et al.* (1970, p. 446). However it is enough for the species to characterize this plant community owing to its rare appearance in the forests. On the other hand, *Rosa acicularis* grows frequently at similar habitats in the Northeast China (Kim 1992).

Jeffersonio-Quercion mongolicae Kim J.W. 1992

The alliance Jeffersonio-Quercion mongolicae (type association: Abieti holophyllae-Quercetum mongolicae) was consisted of plant communities described above. A group of character species such as *Jeffersonia dubia* (Berberidaceae), *Carex drymophila* s.l., *Carex pediformis* var. *reventa*, *Cardamine leucantha*, *Euonymus pauciflorus* and diagnostic species group of the type association are best to express in establishing this alliance.

According to Galikina and Petelin (1990), the broad-leaved forests of Far East is represented by the order Tilietalia amurensis Galk. *et* Pet. (1990). This order was described by two alliances and six associations with emphasis on difference of edaphic aspects as well as diagnostic species. Regrettably the nomenclatural types (Art 5) were not selected anywhere at all. Particularly their syntaxa could not be compared with current units due to great difference in the diagnostic species composition. For example, they presented *Plantago asiatica* as one of the diagnostic species for the association Saussureo grandifoliae-Tilietum amurensis Galk. *et* Pet. 1990. More detailed discussion about all of them will be accomplished in the next work.

(2) Synecology

As shown in Fig. 3, all stands were obviously grouped on the ordination diagram. Human impacts strongly correlated with Axis-I were the most outstanding factor to the disjunction of them. It happened because such anthropogenic factors had direct influence upon the species composition of plant community.

Although relevé No. 30 is an outlier in the numerical treatment, it is considered as an independent significant syntaxon with regard to the qualitative classification (*sensu stricto*). Stands plotted at the bottom of the ordination diagram are neighboring to the *Ulmus laciniata*-*Fraxinus mandshurica* forests at lower slopes and/or near valleys where water condition in the soils is favorable for plant growth. The better examples are the ulmetosum laciniatae and the saniculetosum rubriflorae which are found at the most mesic habitats in the Jeffersonio-Quercion mongolicae.

The subass. circaetosum alpinae was a group of nearly natural stands, the environmental

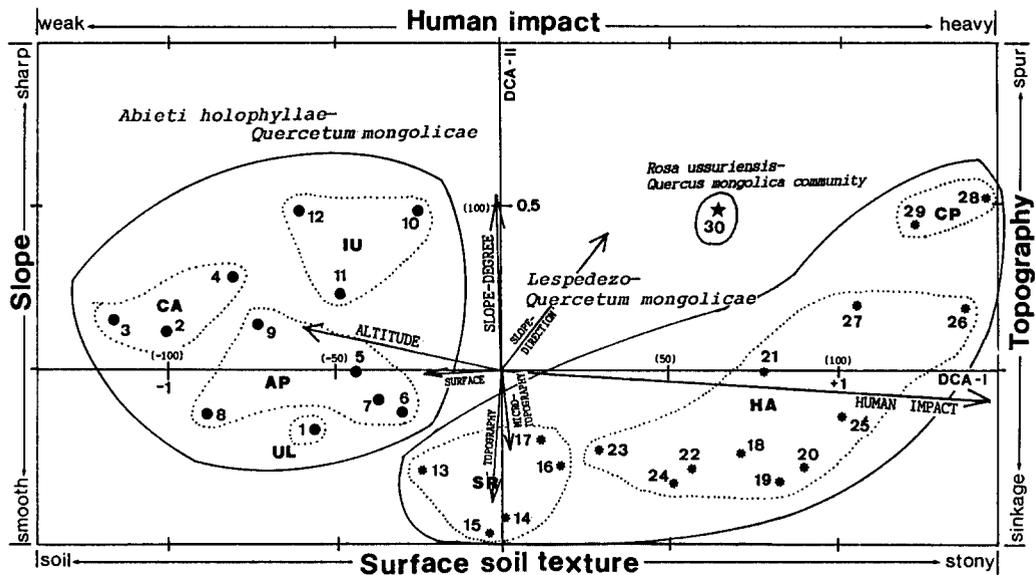


Fig. 3. Plot of the first two axes from detrended correspondence analysis of a matrix of species-relevé and environmental variable-relevé. The arrows indicate environmental variables. The parenthesis scale applies to environmental variables, other scale to species and relevés. Abbreviations show the subassociations: IU-iricetosum uniflorae, CA-circeetosum alpinae, AP-athyrietosum pycnosorum, UL-ulmetosum laciniatae, SR-saniculetosum rubriflorae, HA-hypericetosum ascyron and CP-crataegetosum pinnatifidae. Numbers correspond to running number in Table 1.

condition of which is good enough for *Panax ginseng* (Araliaceae) to occur (e.g. relevé No. 4). This species gets threateningly vanished in the nature nowadays. The iricetosum uniflorae had the smallest species number (av. 44 spp.) within the Jeffersonio-Quercion mongolicae by disturbance of wild deers (e.g. *Cervus nippon hortulorum*) and boars (e.g. *Sus scrofa continentalis*) eating plants in the herb- and shrub-layers. However, species composition of the plant community was basically different from that of the secondary vegetation being regenerated from the human disturbance like fire and clear-cut. This agrees with the fact that such pioneers as *Betula platyphylla* var. *japonica*, *Betula dahurica*, *Tilia mandshurica*, *Corylus heterophylla*, *Dictamnus dasycarpus*, *Lespedeza bicolor*, *Saussurea triangulata*, *Isodon excisus*, and *Adenophora* spp. grow much more frequently in the Lespedezo-Quercetum mongolicae ordinated at the bottom-right of the diagram (Fig. 3).

In addition, *Iris uniflora*, being a differential species for the iricetosum uniflorae, occurs at spherical convex micro-topography like around the base of tree trunks. Such micro-habitat is more or less in dry condition at narrow peaks and in abundant light condition. Similar situation was found at the stand of *Rosa acicularis-Quercus mongolica* community and

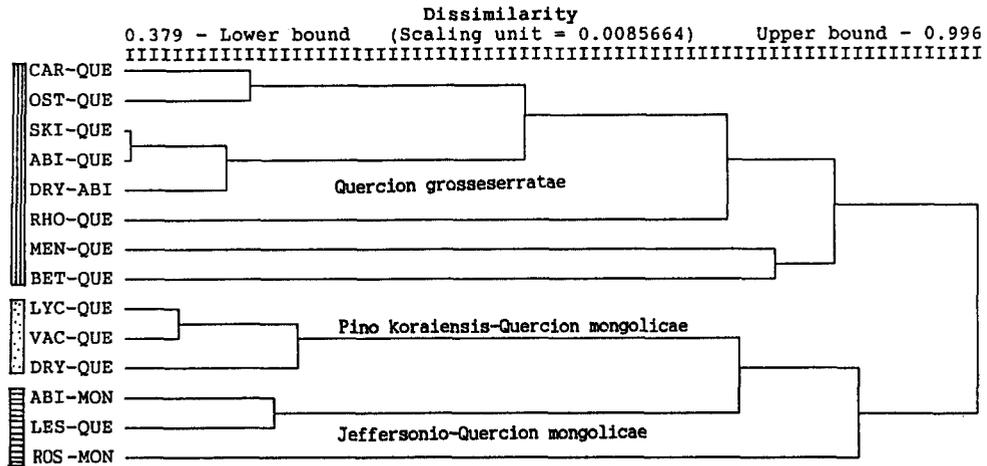


Fig. 4. Dendrogram of the mixed coniferous-broadleaf forests in South Primorye, South Korea and Hokkaido Japan. Abbreviations of objectives correspond to names of plant communities in Table 3.

Tilia amurensis-*Pinus koraiensis* community in the Mts. Shaoshingangrin of Northeast China (Kim 1992) which were developed on the substrates derived from granite.

(3) Syng geography

It is worthy to review the Jeffersonio-*Quercion mongolicae* as a vicarious alliance of the *Pino koraiensis*-*Quercion mongolicae* in the Korean Peninsula and the *Quercion grosseserratae* in Hokkaido, Japan. Because these forests are northernmost vegetation types belonged to the same formation as the cool-temperate coniferous-broadleaf mixed forests around the Tonghae. Owing to their geographical distribution restricted around the Tonghae (Sea of Japan), not the Pacific Ocean, we prefer to use the terminology of these forest types as the “Amphi-Tonghae Mixed-Forests” instead of “Pan-Mixed forests” (*sensu* Tatewaki 1955).

As shown in Fig. 4, plant communities of the Jeffersonio-*Quercion* showed much more affinity to those of the Pino-*Quercion* than to the *Quercion grosseserratae* in clustering analysis on the basis of species composition. This might be simply caused by the connection of lands between two distribution areas. In other words, the *Quercion grosseserratae* of Hokkaido has been geographically isolated from the Asian continent and rather connected to Honshu Japan near the late Pleistocene. Geographical segregation of tree species in Hokkaido may be the most important reason to produce such clustering result. Good examples are *Acer mono* var. *glabrum* and *mayrii*, *Quercus mongolica* var. *grosseserrata*, *Tilia japonica*, *Abies sachalinensis* and *Rhus ambigua*. Furthermore, numbers and performance pattern of common species in three alliances were the most effective in differentiating them, especially those between the *Quercion grosseserratae* and the other two alliances were the

most (Table 7).

Consequently the Jeffersonio-Quercion may be linked to the Pino-Quercion included into the order Rhododendro-Quercetalia mongolicae Kim J.W. 1990. The principal arboreal occurring in this order are *Fraxinus rhynchophylla*, *Acer pseudosieboldianum*, *Corylus sieboldiana* var. *mandshurica*, *Maackia amurensis* and *Tilia amurensis*. These are also significant to identify from the Quercion grosseserratae included into the order Quercetalia serrato-grosseserratae Miyawaki *et al.* 1971 in the Japanese Archipelago (Table 8).

On the other hand, current forests described by alliance level were able to be syngelographically typified from the ordination results (Fig. 5) and above integrated informations. This is well coincided with preliminary suggestion to a synchronology of the Northeast Asian cool-temperate forests (Kim 1989a, 1992). Both Jeffersonio-Quercion and Pino-Quercion are considered as the continental vegetation type, as well as the Quercion grosseserratae as the Hokkaido-subtype of transitional vegetation type in the Northeast Asian cool-temperate forests (Kim 1992). Dwarf bamboos (*Sasa* spp.) dominating almost

Table 8. Characterization of the Coniferous-broadleaf mixed forests in the Northeast Asia in accordance with main species occurring in each stratum of plant community.

Syntaxa	Jeffersonio-Quercion mongolicae	Pino koraiensis-Quercion mongolicae	Quercion grosseserratae
Regions	Southern Primorye	Central & southern Korean Peninsula	Hokkaido Japan
Canopy-layer	<i>Quercus mongolica</i> <i>Abies holophylla</i> (<i>Picea jezoensis</i>) <i>Tilia amurensis</i> <i>Ti. mandshurica</i> <i>Maackia amurensis</i>	<i>Qu. mongolica</i> <i>Ab. holophylla</i> <i>Ab. nephrolepis</i> <i>Ti. amurensis</i> <i>Ma. amurensis</i>	<i>Qu. grosseserrata</i> <i>Ab. sachalinensis</i> <i>Picea jezoensis</i> <i>Ti. japonica</i>
Subtree-layer	<i>Acer mono</i> <i>Acer pseudosieboldianum</i> <i>Fraxinus rhynchophylla</i> <i>Euonymus pauciflorus</i> <i>Carpinus cordata</i>	<i>Ac. mono</i> <i>Ac. pseudosieboldianum</i> <i>Magnolia sieboldii</i> <i>Cornus controversa</i> <i>Fr. rhynchophylla</i> <i>Eu. pauciflorus</i> <i>Ca. cordata</i> <i>Rhododendron schlippenbachii</i>	<i>Ac. mono</i> v. <i>glabrum</i> <i>Ac. mono</i> v. <i>mayrii</i> <i>Ma. obovata</i> <i>Co. controversa</i> <i>Ca. cordata</i> <i>Skimmia repens</i> <i>Hydrangea paniculata</i>
Herb-layer	<i>Jeffersonia dubia</i> <i>Mainthium bifolium</i> <i>Schizandra chinensis</i> <i>Carex drymophilla</i> s. l.	<i>Ainsliaea acerifolia</i> <i>Astilbe koreana</i> <i>Sciz. chinensis</i> <i>Saussurea</i> spp.	<i>Sasa senanensis</i> , <i>Sasa</i> spp. <i>Maianthemum dilatatum</i> <i>Sciz. chinensis</i> <i>Rhus ambigua</i>

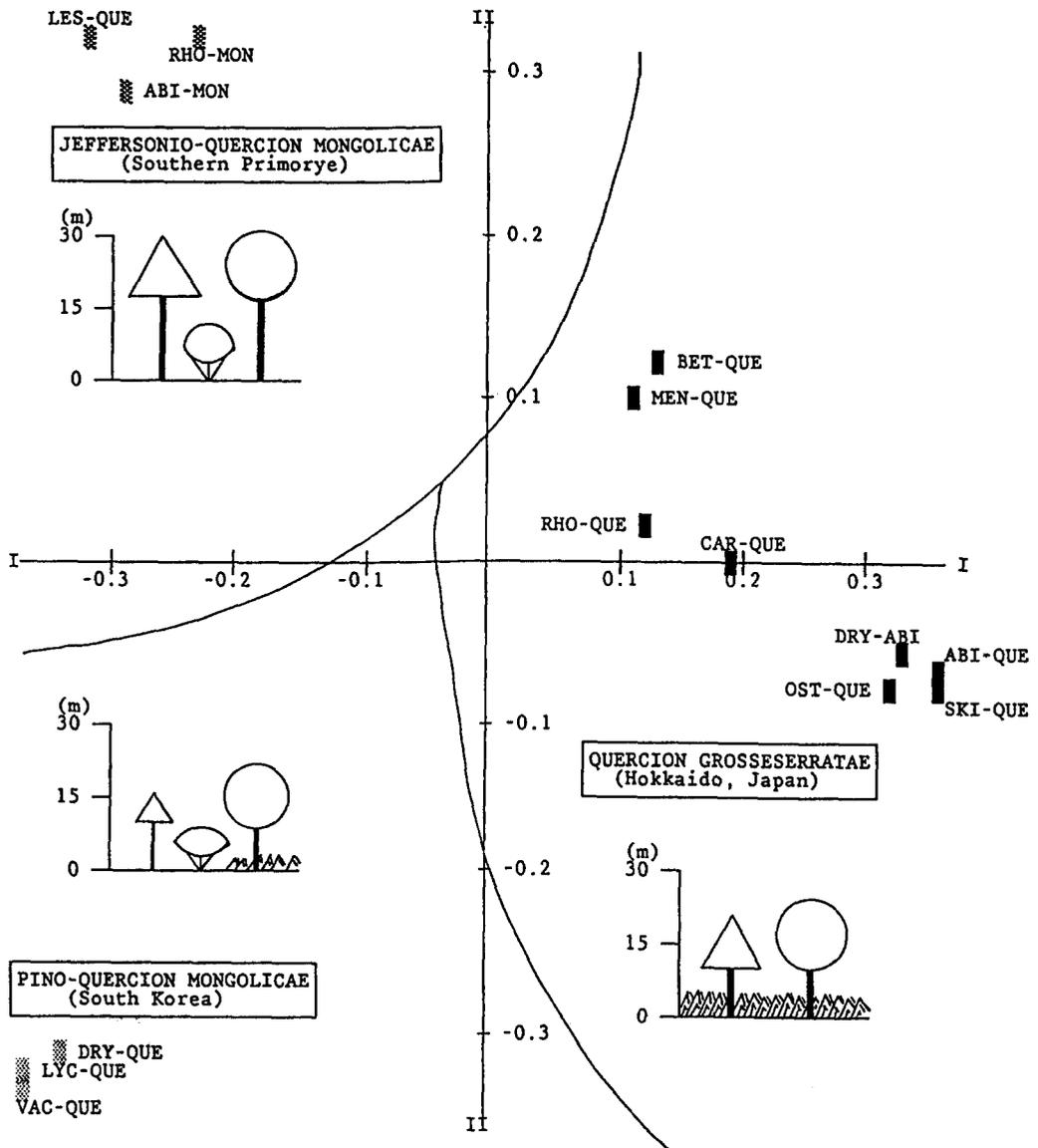


Fig. 5. Ordination and typified scheme of plant communities. Abbreviations correspond to name of plant communities in Table 3.

completely in the *Quercion grosseserratae* are absolutely absent in the *Jeffersonio-Quercion*. Genus *Magnolia* which occurs frequently in the *Quercion grosseserratae* (e.g. *Magnolia obovata*) and the *Pino-Quercion* (e.g. *Magnolia sieboldii*) lacks in the *Jeffersonio-Quercion*. Although there are no paleoecological reports about such genera in southern Sikhote Alin, we believe that such warm-humid preferring plants have completely diminished since the quaternary ice age being unable to survive in the

Eastern-Asiatic refuge (*sensu* Zarzycki 1981). Present climate of this region is already very cold and dry during winter season for the species to grow. Consequently, species composition of the Jeffersonio-Quercion might be much poorer than the other two alliances (Kim 1992). In addition, other structural differences between three alliances are *Jeffersonia dubia*, *Ainsliaea acerifolia* and *Sasa* spp (guerrilla strategy plant, *sensu* Wilson and Lee 1989) to associate highly coherently in the ground layer, respectively. Especially well-development of the geophyte *Jeffersonia dubia* seems to be deeply related to ecological aspects such as enough humidity of air and soils in the southern Primorye region. This species does not occur in the Japanese Archipelago (Table 8). Contrastingly the Hokkaido-subtype can be characterized by the overall abundance of the dwarf bamboos such as *Sasa chartacea*, *Sasa senanensis* and *Sasa kurilensis* which cover the forest floor as a dense but a little shallow jungle. The absence or scarcity of the bamboos in the continental type may explain the higher diversity and different structure. The bamboos with their outstanding life cycle as monocarpic perennials (Gould 1980) may determine the stand structure to an considerable extent (Nakashizuka 1988).

ACKNOWLEDGMENTS

We thank Vladivostok botanists and first author's wife for their kind help in the field works and species identification. They are Dr. A. Nevidomov, Dr. A. Kudinov, Dr. A. Dobrynin, Dr. V. N. Starodubtsev, Dr. V. A. Nedoluzhko, Dr. L. A. Fjedina and Mrs. Kim J. E.

적 요

극동 러시아 남연해주 지역에 있어서 신갈나무림의 최북단 분포형에 대한 종조성에 의한 군락 분류 및 상이한 군락의 종조성을 초래하는 환경요인에 대한 생태학적 연구가 이루어졌다. 식생 분류 및 자료의 수리적 분석을 위하여 전통적 분류 작업, 컴퓨터 프로그램 TWINSpan, CANOCO, SYN-TAX III 등이 이용되었다. DCA (Detrended Correspondence Analysis)에 의해 식물군락의 종조성과 환경요인의 상관분석이 이루어졌으며, 이러한 식생 분석을 위한 수단으로 식물종의 순기여도 (Net Contribution Degree)가 적용되었다.

연구 대상이 된 남연해주 식생은 극동러시아 시호테산맥에 분포하는 냉온대 침활혼합림을 대표하는 식생형으로서 신갈나무-괭괭이풀군단으로 규정되었으며, 신갈나무-전나무군집, 신갈나무-싸리군집, 신갈나무-우수리인가목군락 등의 하위 식물군락을 포함하고 있었다. 식물군락의 종조성과 환경요인의 상관분석에서 인간간섭은 가장 중요한 요인으로 밝혀졌으며, 신갈나무-전나무군집과 신갈나무-싸리군집은 각각 자연식생과 이차식생의 전형적 식생으로 인정되었다.

환동해 지역에 있어서 신갈나무-괭괭이풀군단, 신갈나무-잣나무군단 (한반도), 물참나무군단 (일본북해도) 등의 상호 대응 식생지리형에 대한 단위식생 (Syntaxa)의 종조성적 유사성과 층위 구조에 의한 비교 분석을 통해 신갈나무-괭괭이풀군단은 한반도의 신갈나무-잣나무군단에 더욱 유사하며, 동북아시아에 있어서 해양형에 대응되는 대륙형 냉온대림으로 평가되었다.

LITERATURE CITED

- Academia Sinica. 1985. *Iconographia Cormophytorum Sinicorum*, Tomus I, II, III, IV, V, 1157p., 1312p., 1083p., 932p., 1144p. Co. Scientific Publication, Beijing. (In Chinese).
- Barkman, J.J., J. Moravec and S. Rauschert. 1986. Code of phytosociological nomenclature. Code der pflanzensoziologischen Nomenklatur. Code de nomenclature phytosociologique, 2nd edition. *Vegetatio* 67: 145-195.
- Berg, L.S. 1959. Die geographischen Zonen der Sowjetunion. Band 2. 604 Seiten, mit 136 Bild & 3 Karte. B.G. Teubner Verlagsgesellschaft, Leipzig. (In German).
- Braun-Blanquet, J. 1964. *Pflanzensoziologie*. 3rd ed. Springer, Wien-New York. 631p. (In German).
- Chou, Y.L., S.Y. Li. *et al.* 1990. The forests of China. With distribution map of forests. Academy Publishing Co., Beijing. 550p. (In Chinese).
- Dostalék, J. sen., J. Dostalék, Jr., L. Mucina and H.D. Hwang. 1988. On taxonomy, phytosociology and ecology of some Korean *Rhododendron* species. *Flora* 181: 29-44.
- Galkina M.V. and D.A. Petelin. 1990. Linden forest syntaxonomy in the Far East Reserv. The All-Union Inst. Sci. & Tech. Inform. VINITI, Moskva, Man. N 5135-V90, 58p. (In Russian).
- Gould, S.J. 1980. *Ever Since Darwin, Reflections in Natural History*. Penguin Books, Suffolk. 285p.
- Hea, H.E., E. Landolt and R. Hirzel. 1970. *Flora der Schweiz*. Band 2: Nymphaeaceae bis Primulaceae. Birkh user Verlag, Basel & Stuttgart. 956p. (In German).
- Hill, M.O. 1979. TWINSPAN: A FORTRAN program for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes. Cornell Univ., Ithaca. 89p.
- Hill, M.O. and H.G. Gauch, Jr. 1980. Detrended correspondence analysis: An improved ordination technique. *Vegetatio* 42: 47-58.
- Hou, H.Y. 1983. Vegetation of China with reference to its geographical distribution. *Ann. Missouri Bot. Gard.* 70: 509-548.
- Hokusima, T. and K.N. Kershaw. 1988. The ecology of a beech forest on Mt. Sanpoiwadake, Hakusan Natural Park, Japan. I. Braun-Blanquet, Twinspan and DCA analysis. *Ecol. Res.* 3: 89-100.
- Jeong, H.L. 1992. Phytosociological classification and analysis of conditions of location on the forest vegetation of Mt. Ilwol-san, Ch'ongyang-san and Hakka-san. Master's thesis of Kon Kuk Univ. Seoul. 100p.
- Jongman, R.H.G., Ter Braak, C.J.F. and Van Tongeren, O.F.R. 1987. *Data Analysis in community and landscape ecology*. Pudoc, Wageningen. 299p.
- Kharkewicz, S.S. (ed.). 1978. *Flora i Rastlitelnost Ussuriskogo Zapovednika*. Nauka, Moskva. 269p. (In Russian).

- Kim, J.W. 1989a. Phytosociology and phytogeography of summergreen broad-leaved forests in South Korea. *Studies in Plant Ecology, Uppsala* 18: 141-143.
- Kim, J.W. 1989b. A phytosociological study of Hokkaido vegetation, Japan. *Korean J. Ecol.* 12: 109-122. (In Korean with English abstract).
- Kim, J.W. 1990. Syntaxonomic scheme for the deciduous oak forests in South Korea. *Abstracta Botanica* 14: 51-81.
- Kim, J.W. 1992. Vegetation of Northeast Asia, on the syntaxonomy and syneography of the oak and beech forests. Ph. D. Thesis. Vienna Univ., Vienna. 314p.
- Kolesnikov, B.P. 1956. *Kedrovie lesa Dal'nego Vostoka*. AN SSR, Moskva-Leningrad. 261p. (In Russian).
- Kolesnikov, B.P. 1961. *Rastitel'nost'*. In: *Dal'niy Vostok*, pp. 183-245. AN SSR, Moskva. (In Russian).
- Korotkov, K., O. Morozova and E. Belonovskaja. 1991. The USSR vegetation syntaxa prodromus. Vilchek G. E. publ. Moscow. 346p.
- Kudinov, A.I. 1989. Restoration succession in a *Pinus koraiensis* forest with *Carpinus cordata* and *Picea ajanensis* at the Ussuriysk Reserve. *Lesovedenie* 1: 32-39. (In Russian with English summary).
- Kurentsova, G.E. 1968. *Rastitel'nost' Primorskogo kraja*. Vladivostok. 192p. (In Russian).
- Lee, T.B. 1979. *Illustrated flora of Korea*. Hyangmun-sa., Seoul. 990p. (In Korean).
- Lee, S.H. and K.C. Lee. 1986. A study of characteristics of the plant community on the Myohyangsan Mt. *Rep. Bot. Inst. Acad. Sci. Pyongyang* 3: 8-16. (In Korean).
- Lee, W.T., W.K. Paik and M.K. Kim. 1994. A phytosociological study on the Mongolian oak (*Quercus mongolica*) forests in Mt. Sorak, Korea. *Korean J. Ecol.* 17: 319-331. (In Korean).
- Miyawaki, A. (ed.). 1988. *Vegetation of Japan. Vol. 9. Hokkaido*. Shibundo, Tokyo. 563p. (In Japanese with English & German summary).
- Miyawaki, A. and J.W. Kim. 1985. Phytosociological study of the vegetation of Shonan Sea Shore, Kanagawa Prefecture. *Bull. Inst. Sci. Technol., Yokohama Nat'l. Univ.* 12: 105-124.
- Mucina, L. and E. van der Maarel. 1990. Twenty years of numerical syntaxonomy. *Vegetatio* 81: 1-15.
- Nakashizuka, T. 1988. Regeneration of beech (*Fagus crenata*) after the simultaneous death of undergrowing dwarf bamboo (*Sasa kurilensis*). *Ecol. Res.* 3: 21-35.
- Ohwi, T. 1978. *Flora of Japan*. Shibundo, Tokyo. 1584p. (In Japanese).
- Podani, J. 1988. *Syn-Tax III: user's manual*. *Abstracta Botanica* 12: 1-177.
- Smagin, V.N. 1965. *Lesa basseina Ussuri*. Nauka, Moskva. 271p. (In Russian).
- Sochava, V.A. 1944. *Opit phylotsenogeneticheskoi sistematiki rastitel'nikh assotsiatsii*. *Sovetskaya Botanika* 1: 3-18. (In Russian).
- Sochava, V.A. 1946. *Voprosi florogenesa i phylotsenogenesa manchurskogo smeshannogo*

- lesa. Materiali po istorii flori i rastitel'nosti SSR 2: 283-320. Moskva-Leningrad. (In Russian).
- Solodukhin, E.D. 1965. Lesovodstvennie osnovi chozyaistva v kedrovych lesakh Dal'nego Vostoka Vladivostok. 367p. (In Russian).
- Solov'ev, K.P. 1958. Kedrovo- shirokolisvennie lesa Dal'nego Vostoka i chozyaistvo v nich. Khabarovsk. 367p. (In Russian).
- Song, J.S. 1988. Phytosociological study of the mixed coniferous and deciduous broad-leaf forests in South Korea. *Hikobia* 10: 145-156. (In Japanese with English abstract).
- Suzuki, S. 1988. *Abies sachalinensis-Quercus mongolica* var. *grosseserrata* forests. In A. Miyawaki (ed.). *Vegetation of Japan*. Shibundo, Tokyo. pp. 170-176. (In Japanese).
- Takeda, Y., J. Uemura and S. Nakanishi. 1983. On the *Quercus mongolica* var. *grosseserrata* forests in Hokkaido. *Kobe Univ.* 72: 145-154. (In Japanese with English summary).
- Tatewaki, M. 1955. The Pan-Mixed Forest Zone. *Hoppo Ringyo* (Forestry in Northern Region) 7: 8-11. (In Japanese).
- Ter Braak, C.J.F. 1988. CANOCO - a FORTRAN program for canonical community ordination by correspondence analysis, principal components analysis, and redundancy analysis. 95p. Rep. Agricultural Mathematics Group, Wageningen.
- Tohyama, M. and Y. Mochida. 1978. Vegetation of the deciduous broad leaved forest of eastern part of Iburi District in Hokkaido. *Papers on Plant Ecology & Taxonomy to the Memory for Dr. K. Yoshioka*. pp. 134-149. Sendai. (In Japanese with English summary).
- Tokyo Astronomical Observatory. 1988. *Chronological Scientific Tables*. No. 661. Maruzen Co., LTD. Tokyo. 1011p. (In Japanese).
- Tseplaev, V.P. (translated by A. Gourevitsch). 1965. The forests of the U. S. S. R. Israel Program for Scientific Translation Ltd., Jerusalem, 521p.
- Van der Maarel, E. 1979. Transformation of cover-abundance values in phytosociology and its effects on community similarity. *Vegetatio* 39: 97-114.
- Van der Maarel, E., R. Boot, D. Van Dorp and J. Rijntjes. 1985. Vegetation succession on the dunes near Oostvoorne, The Netherlands: a comparison of the vegetation in 1959 and 1980. *Vegetatio* 58: 137-187.
- Voroshilov, V.N. 1982. Determination key of plants in the Soviet Far East. Leningrad Nauka, Moskow. 672p. (In Russian).
- Westhoff, V. and E. van der Maarel. 1973. The Braun-Blanquet approach. In H. Whittaker (ed.). *Ordination and Classification of Community*. Dr. W. Junk b.v. Publishers, The Hague. pp. 619-658.
- Wildi, O. 1980. Management and multivariate analysis of large data sets in vegetation research. *Vegetatio* 42: 175-180.
- Wilson, J.B. and W.G. Lee. 1989. Infiltration invasion. *Functional Ecology* 3: 379-380.
- Yang, H.X. and Y.G. Wu. 1987. Background to the forest ecosystem and protection of natural resources, Tree composition: Age structure and regeneration strategy of the

mixed broadleaved / *Pinus koraiensis* (Korean pine) forest in Changbai Mountain Reserve. In Yang *et al.* (ed.). The Temperate Forest Ecosystem. The Lavenham Press, Lavenham Suffolk. pp. 12-20.

Zarzycki, K. 1981. Notes on the contemporary vegetation of the southeastern United States and the Pliocene vegetation of the West Carpathian Mountains in Europe: an attempt at comparison. Veröf. Geobot. Inst. ETH, Stiftung Rübel 77: 73-111.

(Received 25 August, 1994)