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

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극동러시아 남연해주의 냉온대 침활혼합림의 군락분류 및 분포적 특성

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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 synchorologically 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 relevê 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 syngeographical 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-

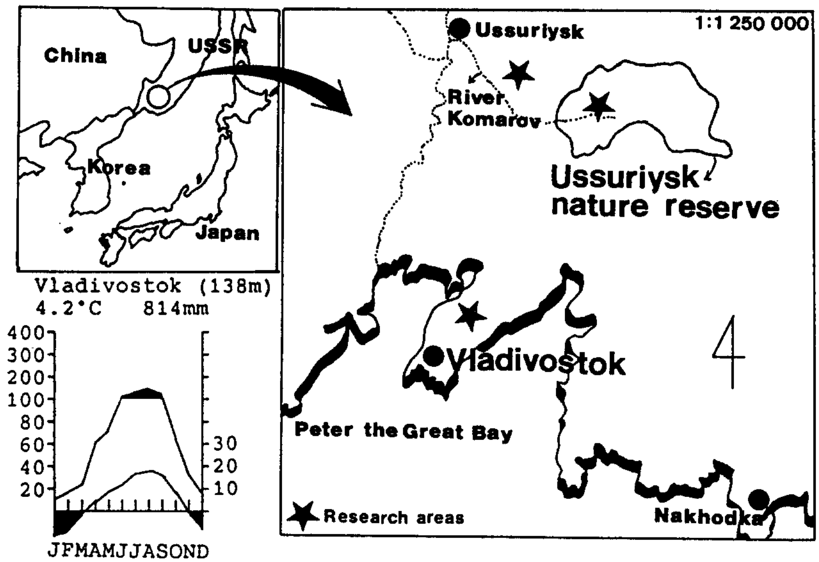

Fig. 1. Geography and climate of investigated areas.

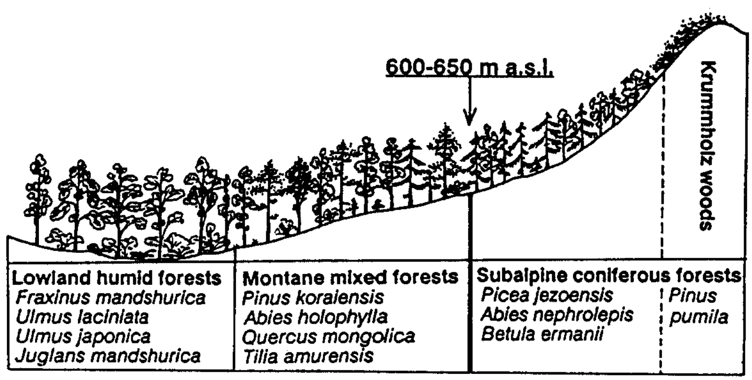

Fig. 2. General scheme of distribution pattern of forest vegetation in the southern Primorye region.

bution 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 ℃ 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 ℃ 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	S	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	250	400	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	1.5	1	1	1.5	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	5	4	1	1	5	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	4	3	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	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	5	5	5	5	3

Notes: A - Running no. ; B - Relevé no. ; C - Altitude (m); D - Slope; E-Inclination (°); F - Area (m^2); 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 variabes 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				
7	West				
8	NW				
9	L				

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)

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. (1988)
CAR-QUE	Carpino-Quercetum grosseserratae*	61	343	
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	*Menziesia pentandra-Quercus grosseserrata* comm.	4	42	
BET-QUE	*Betula tauschii-Quercus grosseserrata* comm.	5	58	
RHO-QUE	*Rhododendron kaempferi-Quercus grosseserrata* comm.	4	83	
Pino koraiensis-Quercion mongolicae (Korean Peninsula)		55	351	Kim (1990)
LYC-QUE	Lychno-Quercetum mongolicae	12	196	
VAC-QUE	Vaccinio-Quercetum mongolicae	25	201	
DRY-QUE	Dryopterido-Quercetum mongolicae	18	234	
Jeffersonio-Quercion mongolicae (Southern Primorye)		30	268	Kim (1992)
ABI-MON	Abieti holophyllae-Quercetum mongolicae	12	174	
LES-QUE	Lespedezo-Quercetum mongolicae	17	216	
ROS-MON	*Rosa ussuriensis-Quercus mongolica* 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:

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

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:

$$R\text{-}NeCD = NeCD_i / NeCD_{max} \times 100 \text{ ------------------ } (2)$$

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.:		0 1	000 234	00000 56789	111 012	CD	NeCD
Abieti holophyllae-Quercetum mongolicae							
Pinus koraiensis S. et Z.	Ch :	1	343	++212	323	V	5.083
Syringa amurensis Rupr.	Ch :	1	+++	+2++2	+12	V	2.916
Carpinus cordata Bl.	Ch :	2	221	4+121	.+.	V	2.847
Carex ussuriensis Kom.	Ch :	.	223	+.++1	+++	V	2.222
Acer barbinerve Max.	Ch :	2	2++	++111	+..	V	2.013
Lonicera praeflorens Batal.	Ch :	.	1++	+.+.+	++1	IV	1.250
Acanthopanax senticosus (R. et M.) H.	Ch :	+	+++	..+1.	+.+	IV	0.944
Acer tegmentosum Max.	Ch :	+	+++	+1.1.	...	III	0.777
Abies holophylla Max.	D :	.	232	23121	+1+	V	3.590
Maianthemum bifolium (L.) F. W. Schm.	D :	1	+++	1++2+	.+.	V	1.736
Oxalis acetosella L.	D :	2	111	+.+2+	..+	IV	1.687
ulmetosum laciniatae							
Phellodendron amurense Rupr.	D :	1	...	..1..	...	I	0.083
Fraxinus mandshurica Rupr.	D :	1	...	....+	...	I	0.069
Prunus padus L. s.l.	D :	+	...	..1..	...	I	0.069
Alnus hirsuta (Spach) Rupr.	D :	2	...	.....	...	I	0.034
Ulmus laciniata (Trautv.) Mayr	D :	1	...	.....	...	I	0.020
Caulophyllum robustrum Max.	D :	+	...	.....	...	I	0.013
Cimicifuga dahurica Max.	D :	+	...	.....	...	I	0.013
circaeetosum alpinae							
Diarrhena mandshurica Max.	D :	.	1++	....+	1..	III	0.416
Ribes mandshuricum Kom.	D :	+	+++	.+...	...	III	0.347
Spiraea ussuriensis Pojark	D :	1	+++	.....	...	II	0.250
Circaea alpina L.	D :	.	1+2	.....	...	II	0.208
Acer mandshuricum Max.	D :	.	1++	.....	...	II	0.145
athyrietosum pycnosorum							
Pyrola japonica Klenze	D :	.	...	+++++	..+	III	0.500
Athyrium pycnosorum H. Christ	D :	.	+..	++++.	...	III	0.347
Prunus maximowiczii Rupr.	D :	.	1..	.++1.	...	II	0.277
Polemonium racemosum (Regel) Kitamura	D :	.	...	.++++	...	II	0.222
Athyrium spinulosum (Max.) Milde	D :	.	...	+++.+	...	II	0.222
Lathyrus komarovii Ohwi	D :	.	...	..+++	.+.	II	0.222
Artemisia sylvatica Max.	D :	.	...	.+++.	...	II	0.125
Campanula punctata Lam.	D :	.	...	..+++	...	II	0.125
Circaea cordata Royle	D :	.	...	..+.1	...	I	0.069
Osmundastrum cinna. v. fokiense (C.) T.	D :	.	...	+.1..	...	I	0.069
iricetosum uniflorae							
Aralia elata Seem.	D :	.	...	1	+++	II	0.250
Iris uniflora Pall. ex Link	D :	.	...	.....	+++	II	0.125

Table 4. Continued.

Viola orientalis W. Becker	D :	. ... +.+	I	0.055
Bupleurum longiradiatum Turcz.	D :	. ... +.+	I	0.055
Fragaria orientalis Losinsk.	D :	. ... +.+	I	0.055
Jeffersonio-Quercion mongolicae				
Carex drymophila v. abbreviata (Kü.) Oh.	Ch :	+ 1++ ++3+1 .++	V	2.215
Convallaria keiskei Miq.	Ch :	. +++ 1++++ +++	V	1.756
Euonymus pauciflorus Max.	Ch :	+ .++ 1++++ .++	V	1.458
Jeffersonia dubia Benth.	Ch :	. .1+ +++++ ++.	IV	1.187
Carex pediformis v. reventa (V. Kre.) W.	Ch :	. ... ++.+. 333	III	1.125
Actinidia kolomikta (M. et R.) Max.	Ch :	1 +++ +++1. ...	IV	1.000
Betula dahurica Pall.	Ch :	. 11. 1112. ...	III	0.833
Cardamine leucantha O. E. Schulz	Ch :	. ++. ...++ ++.	III	0.500
Rhododendro-Quercetalia mongolicae				
Quercus mongolica Fisch.	Ch :	2 111 55433 232	V	5.916
Acer pseudosieboldianum (Pax.) Kom.	Ch :	1 +1+ 3+2.2 141	V	3.284
Tilia amurensis Rupr.	Ch :	+ +11 2+.++ +1+	V	2.138
Corylus sieb. v. mandshurica (M.)C.K.S.	Ch :	. ++. +++++ +++	V	1.388
Fraxinus rhynchophylla Hance	Ch :	. +.. 1+1++ ++.	IV	1.000
Maackia amurensis 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 Lespedezo-Quercetum mongolicae.
SR : saniculetosum rubriflorae HA : hypericetosum ascyron
CP : crataegetosum pinnatifidae

Unit:		SR	HA	CP	Synoptic values	
Running No.:		11111 34567	1122222222 8901234567	22 89	CD	NeCD
Lespedezo-Quercetum mongolicae						
Carex lanceolata A. Gray	Ch:	.+..+	22+2212135	1+	V	2.809
Lespedeza bicolor Turcz.	Ch:	..+.+	1++++++1+4	31	V	2.034
Corylus heterophylla Fish. Bl.	Ch:	+...+	+++2+1+31+	1+	V	1.889
Convallaria keiskei Miq.	Ch:	++.++	11++11++++	..	V	1.550
Artemisia sylvatica Max.	Ch:	...++	111.+.112+	2+	IV	1.453
Vicia unijuga A. Br.	Ch:	.+.++	..+.+1++++	21	IV	1.204
Isodon excisus (Max.) Kudo	Ch:	++2+.	++++++++..	..	IV	1.121
Geranium eriostemon Fisch.	Ch:	+...+	.++++++.++	+.	IV	0.837
Chloranthus japonica Sieb.	D:	+1++1	.......1++	.+	III	0.653
Artemisia keiskeana Miq.	D:	.....	...1.+..+.	2+	II	0.242
saniculetosum rubriflorae						
Dryopteris crassirhizoma Nakai	D:	.+3+.	...+......	..	II	0.179
Sanicula rubriflora Fr. Schm.	D:	+++++	....	..	II	0.173

Table 5. Continued.

Polemonium racemosum (Regel) Kitamura	D:	.+++. ......1... ..	II	0.124
Cypripedium calceolus L.	D:	.++.+ ....+. ..	II	0.110
Pyrola japonica Klenze	D:	.+.++ ....+..... ..	II	0.110
Adianthum pedatum L.	D:	+++..	I	0.062
Paris verticillata M. v. Bieb.	D:	+++..	I	0.062
hypericetosum ascyron				
Adenophora triphylla v. hirsuta Nakai	D:	....+ +++++...++ ..	III	0.442
Vicia venosa v. baicalensis (T.) Worosch	D:	..... .++++..++. +.	III	0.339
Potentilla fragaroides L.	D:	..... +.+.+++.+. +.	III	0.339
Potentilla fragaroides v. major Max.	D:	..... .++..1+++. ..	II	0.269
Codonopsis lanceolata (S. et Z.) Trautv.	D:	..... +1+.++.+.. ..	II	0.269
Galium spurium L.	D:	..... +...12+..1 ..	II	0.259
Hypericum ascyron L.	D:	..... ++...++.++ ..	II	0.249
Viola collina Hemsl.	D:	....+.+..+++ .+	II	0.249
Dictamnus dasycarpus Turcz.	D:	..... .+.1...1.+ +.	II	0.207
Variant Anemone udensis				
Betula platyphylla v. japonica Hara	D:	+.... 1211+22... 1.	III	0.965
Filipendula palmata (Pall.) Maxim.	D:	..++. ++++1++... ..	III	0.591
Angelica sachalinensis Mixim.	D:	...++ +++++.+... .+	III	0.560
Anemone udensis Trauv. et Mey.	D:	..... ++++++.... ..	II	0.249
Muhlenbergia japonica Steudo.	D:	..... .+++..2... ..	II	0.152
Bupleurum longiradiatum Turcz.	D:	....++++... ..	II	0.110
Diarrhena mandshurica Max.	D:	....111... ..	I	0.093
crataegetosum pinnatifidae				
Peucedanum terebinthaceum Fisch.	D:	....+ 1+	I	0.072
Crataegus pinnatifida Bunge	D:	.... +1	I	0.034
Artemisia gmelinii Web. ex Stechm.	D:	.... ++	I	0.027
Acer barbinerve Max.	D:	.... ++	I	0.027
Jeffersonio-Quercion mongolicae				
Jeffersonia dubia Benth.	Ch:	+11++ 11.++21+.+ ..	IV	1.529
Betula dahurica Pall.	Ch:	.11.1 1211.1.1.1 1.	IV	1.332
Carex drymophila v. abbreviata (Kü.) Oh.	Ch:	.311+ 21+1+++... ..	IV	1.294
Cardamine leucantha O. E. Schulz	Ch:	1+1++ ....+.++.. .+	III	0.622
Carex pediformis v. reventa (V. Kre.) W.	Ch:	+.1++ ....+..1.. .+	III	0.387
Euonymus pauciflorus Max.	Ch:	+1... +++.1+.... ..	III	0.387
Actinidia kolomikta (M. et R.) Max.	Ch:	1.+.1 .++..+.... ..	II	0.290
Rhododendro-Quercetalia mongolicae				
Quercus mongolica Fisch.	Ch:	35533 5555545554 25	V	8.294
Tilia amurensis Rupr.	Ch:	+1112 12++111111 +.	V	2.657
Fraxinus rhynchophylla Hance	Ch:	+1++. 11++2++11+ 2+	V	2.380
Corylus sieb. v. mandshurica (M.) C.K.S.	Ch:	1+21+ 1+++++1.+. ..	IV	1.484
Maackia amurensis Rupr. et Max.	Ch:	+111. +++1+11... +.	IV	1.245
Acer pseudosieboldianum (Pax.) Kom.	Ch:	.++.. 12+++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:			
Rosa ussuriensis	2	*Iris uniflora*	+
Rhododendron mucronulatum	4	*Gymnocarpium dryopteris*	+
Lespedeza bicolor	1	*Dictamnus dasycarpus*	1
Viola orientalis	+	*Carex lanceolata*	1
Character spp. of Jeffersonio-Quercion mongolicae:			
Betula dahurica	1	*Carex pediformis* v. *reventa*	+
Pinus koraiensis	+	*Carex drymophila* v. *abbreviata*	2
Euonymus pauciflorus	+		
Character spp. of Rhododendro-Quercetalia mongolicae			
Quercus mongolica	3	*Tilia amurensis*	+
Pyrola japonica	+	*Corylus sieb.* v. *mandshurica*	+
Acer mono	1		
Companions:			
Waldsteinia ternata	+	*Cimicifuga dahurica*	+
Tulotis asiatica	+	*Artemisia keiskeana*	1
Schizandra chinensis	+	*Peucedanum terebinthaceum*	+
Muhlenbergia japonica	+	*Potentilla fragaroides*	+
Ulmus davidiana v. *japonica*	+	*Aster scaber*	+
Viola acuminata	+	*Fragaria orientalis*	+
Tilia mandshurica	+	*Atractylodes japonica*	+
Sanguisorba officinalis	+	*Vicia amurensis*	+
Melampyrum roseum	+	*Arundinella hirta*	2
Potentilla fragaroides v. *major*	+	*Caragana fruticosa*	+
Lysimachia vul. v. *dahurica*	+	*Carex sp.-I*	+
Rubia chinensis	+	*Veratrum maackii s. l.*	+
Synurus deltoides	+	*Betula platyphylla* v. *japonica*	+
Calamagrostis sp-I	+	*Galium spurium*	+

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 identitied 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 relevê 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

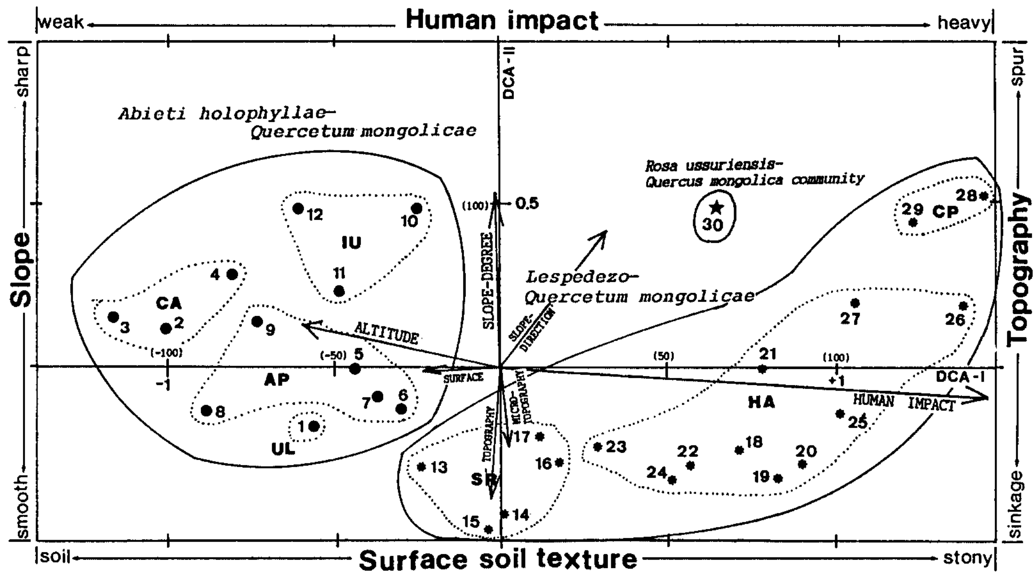

Fig. 3. Plot of the first two axes from detrended correspondence analysis of a matrix of species-relevé and envirnmental variable-relevé. The arrows indicate environmental variables. The parenthesis scale applies to environmental variables, other scale to species and relevés. Abbreviations show the subassociations: 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 accur (*e.g.* relevé No. 4). This species gets threateningly vanished in the nature nowaday. The iricetosum unifloae 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 microhabitat 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

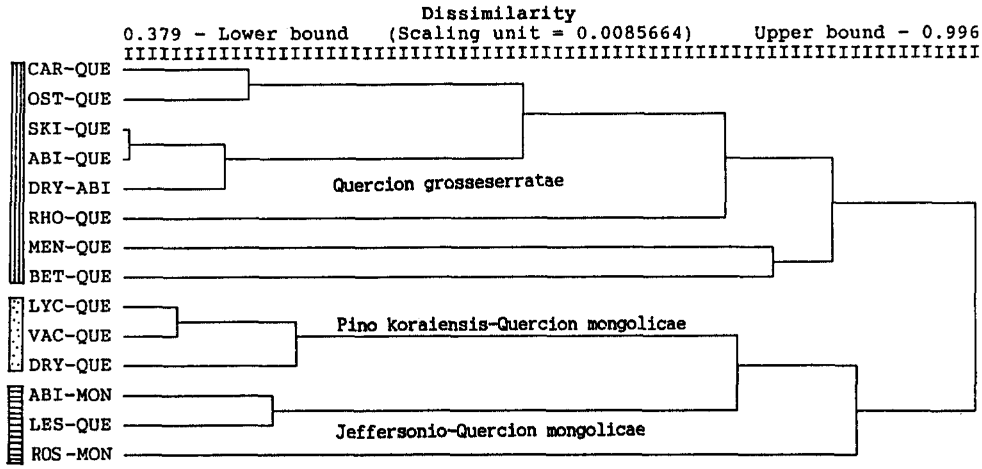

Fig. 4. Dendrogram of the mixed coniferous-broadleaf forests in South Primorye, South Korea and Hokkaido Japan. Abbreviations of objectives correspond to names of plant communities in Table 3.

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

(3) Syngeography

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 resticted 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

Table 7. Synthesized table by constancy degree (I ~ V) and relative net-contribution degree (1~100) of species in the alliances. Sources of data are summerized in Table 3.

Quercion grosseserratae	QG	
Quercus mongolica var. grosseserrata	V	100
Tilia japonica	III	16
Abies sachalinensis	III	15
Rhus ambigua	III	15
Sasa chartacea	II	13
Acer mono Maxim. var. glabrum	III	10
Acer mono Maxim. var. mayrii	III	11
Sasa senanensis	II	9
Acer japonicum	III	8
Magnolia obovata	III	8
Viburnum furcatum	II	7
Hydrangea petiolaris	III	6
Vitis coignetiae	III	6
Schizophragma hydrangeoides	II	5
Acer palmatum var. matsumurae	II	5
Fraxinus lanuginosa	II	5
Hydrangea paniculata	II	5
Sasa kurilensis	II	5
Pachysandra terminalis	II	4
Cimicifuga simplex	II	3
Trillium kamtschaticum	II	2

Pino koraiensis-Quercion mongolicae	PQ	
Rhododendron schlippenbachii	V	31
Ainsliaea acerifolia	IV	18
Astilbe koreana	IV	15
Calamagrostis arundinacea	III	14
Sasa borealis	II	9
Magnolia sieboldii	III	8
Pseudostellaria palibiniana	III	7
Astilbe koreana	II	4
Lindera obtusiloba	II	4
Angelica gigas	II	3
Abies nephrolepis	II	2
Astilbe chinensis var. davidii	II	2
Carex humilis	II	2
Fraxinus sieboldiana	II	2
Hepatica asiatica	II	2
Lespedeza tomentella	II	2
Pimpinella brachycarpa	II	2
Acer tschonoskii v. rubripes	II	2

Jeffersonio-Quercion mongolicae	JQ	
Carex drymophila var. abbreviata	IV	21
Jeffersonia dubia	IV	18
Betula dahurica	III	16
Galium dahuricum	IV	14
Syringa amurensis	III	11
Tilia mandshurica	III	10
Carex pediformis var. reventa	III	10
Corylus heterophylla	III	9
Juglans mandshurica	III	8
Vicia venosa var. baicalensis	III	6
Carex ussuriensis	II	6
Cacalia auriculata v. auriculata	II	5
Galium spurium	II	5
Maianthemum bifolium	II	5
Anemone udensis	II	4
Athyrium spinulosum	II	4
Cynanchum ascyrifolium	II	4
Filipendula palmata	II	4
Geranium eriostemon	II	4
Pseudostellaria sylvatica	II	4
Fragaria orientalis	II	3
Muhlenbergia japonica	II	3
Saussurea triangulata	II	3
Vicia amurensis	II	3
Adenophora triphylla v. hirsuta	II	2
Angelica sachalinensis	II	2
Campanula punctata	II	2
Cimicifuga dahurica	II	2
Dictamnus dasycarpus	II	2
Euphorbia sieboldiana	II	2
Polemonium racemosum	II	2
Potentilla fragaroides	II	2
Trigonotis coreana	II	2

Quercion grosseserratae / Pino-Quercion	QG		PQ		JQ
Prunus sargentii	III	6	II	1	
Euonymus oxyphyllus	II	3	III	5	
Betula ermanii	II	3	II	3	
Dryopteris austriaca	II	3	II	2	
Rhus trichocarpa	II	3	I	1	
Disporum smilacinum	I	1	III	5	
Cornus controversa	I	1	II	3	
Maianthemum dilatatum	III	9	I	-	
Euonymus alatus for. ciliato-dentatus	II	3	I	-	
Cacalia hastata ssp. orientalis	II	2	I	-	
Solidago virga-aurea v. asiatica	I	-	III	8	
Symplocos chinensis for. pilosa	I	-	III	7	
Veratrum maackii v. japonicum	I	-	II	3	
Corylus sieboldiana	I	-	II	2	

Pino-Quercion / Jeffersonio-Quercion	QG	PQ		JQ	
Quercus mongolica		V	100	V	100
Acer pseudosieboldianum		V	29	IV	23
Tilia amurensis		IV	16	V	32
Fraxinus rhynchophylla		III	6	V	24
Pinus koraiensis		III	8	III	19
Thalictrum filamentosum		II	3	IV	22
Maackia amurensis		II	3	IV	15
Abies holophylla		II	2	III	10
Asarum sieboldii		II	2	III	8
Isodon excisus		II	2	III	7
Melampyrum roseum		II	1	II	1
Corylus sieb. v. mandshurica		I	1	IV	20
Philadelphus schrenckii		I	1	IV	20
Acer barbinerve		I	1	II	6
Pedicularis resup. v. oppositifolia		II	4	I	-
Viola orientalis		II	3	I	-
Euonymus pauciflorus		I	-	III	11
Artemisia sylvatica		I	-	III	9
Vitis amurensis		I	-	III	8
Lonicera praeflorens		I	-	III	7
Viola acuminata		I	-	III	6
Aruncus dioicus v. kamtschaticus		I	-	II	5
Diarrhena mandshurica		I	-	II	3
Dioscorea nipponica		I	-	II	4
Viola collina		I	-	II	4

Quercion grosseserratae / Jeffersonio-Quercion			PQ	JQ	
Phryma leptostachya v. asiatica	II	1		IV	14
Euonymus alatus	I	-		IV	13
Acanthopanax senticosus	I	-		III	6
Betula platyphylla v. japonica	I	2		III	10
Lespedeza bicolor	I	1		III	11
Ulmus davidiana v. japonica	I	1		III	12
Malus baccata v. mandshurica	I	-		II	3
Oxalis acetosella	I	-		II	4
Pteridium aquilinum v. latiusculum	I	1		II	3
Solidago virga-aurea v. leiocarpa	I	1		II	3
Waldsteinia ternata	I	-		II	4

Common species in three alliances	QG		PQ		JQ	
Kalopanax pictus	IV	25	II	3	I	1
Sorbus alnifolia	III	13	II	3	III	6
Carpinus cordata	III	11	II	5	II	7
Dryopteris crassirhizoma	III	12	II	3	II	6
Sorbus commixta	II	6	II	3	I	-
Schizandra chinensis	II	4	I	1	IV	21
Actinidia kolomikta	II	2	I	-	III	7
Cardamine leucantha	II	2	I	-	III	7
Chloranthus japonica	II	1	I	-	II	3
Carex siderosticta	I	-	V	39	IV	19
Acer mono	I	1	III	5	V	38
Athyrium yokoscense	I	-	III	8	I	-
Codonopsis lanceolata	I	-	II	1	II	2
Actaea asiatica	I	1	II	2	I	1
Aster scaber	I	-	II	2	I	2
Smilacina japonica	I	1	II	2	I	1
Convallaria keiskei	I	-	I	-	V	21
Carex lanceolata	I	1	I	1	IV	22
Polygonatum involucratum	I	-	I	-	III	10
Viburnum sargentii	I	-	I	-	III	5
Vicia unijuga	I	-	I	-	III	6
Pyrola japonica	I	-	I	-	II	4

Notes : Species listed up compose of species presenting above II (≥II) in each column and occurring in two alliances if larger than 2 in relative net-contribution degree.

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 arbores 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 syngeographically typified from the ordination results (Fig. 5) and above integrated informations. This is well coincided with preliminary suggestion to a synchorology 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	*Quercus mongolica*	*Qu. mongolica*	*Qu. grosseserrata*
	Abies holophylla	*Ab. holophylla*	*Ab. sachalinensis*
		Ab. nephrolepis	
	(Picea jezoensis)		*Picea jezoensis*
	Tilia amurensis	*Ti. amurensis*	*Ti. japonica*
	Ti. mandshurica		
	Maackia amurensis	*Ma. amurensis*	
Subtree-layer	*Acer mono*	*Ac. mono*	*Ac. mono* v. *glabrum*
			Ac. mono v. *mayrii*
	Acer pseudosieboldianum	*Ac. pseudosieboldianum*	
		Magnolia sieboldii	*Ma. obovata*
		Cornus controversa	*Co. controversa*
	Fraxinus rhynchophylla	*Fr. rhynchophylla*	
	Euonymus pauciflous	*Eu. pauciflous*	
	Carpinus cordata	*Ca. cordata*	*Ca. cordata*
		Rhododendron schlippenbachii	
			Skimmia repens
			Hydrangea paniculata
Herb-layer	*Jeffersonia dubia*	*Ainsliaea acerifolia*	*Sasa senanensis, Sasa* spp.
	Mainthemum bifolium	*Astilbe koreana*	*Maianthemum dilatatum*
	Schizandra chinensis	*Sciz. chinensis*	*Sciz. chinensis*
	Carex drymophilla s. l.	*Saussurea* spp.	*Rhus ambigua*

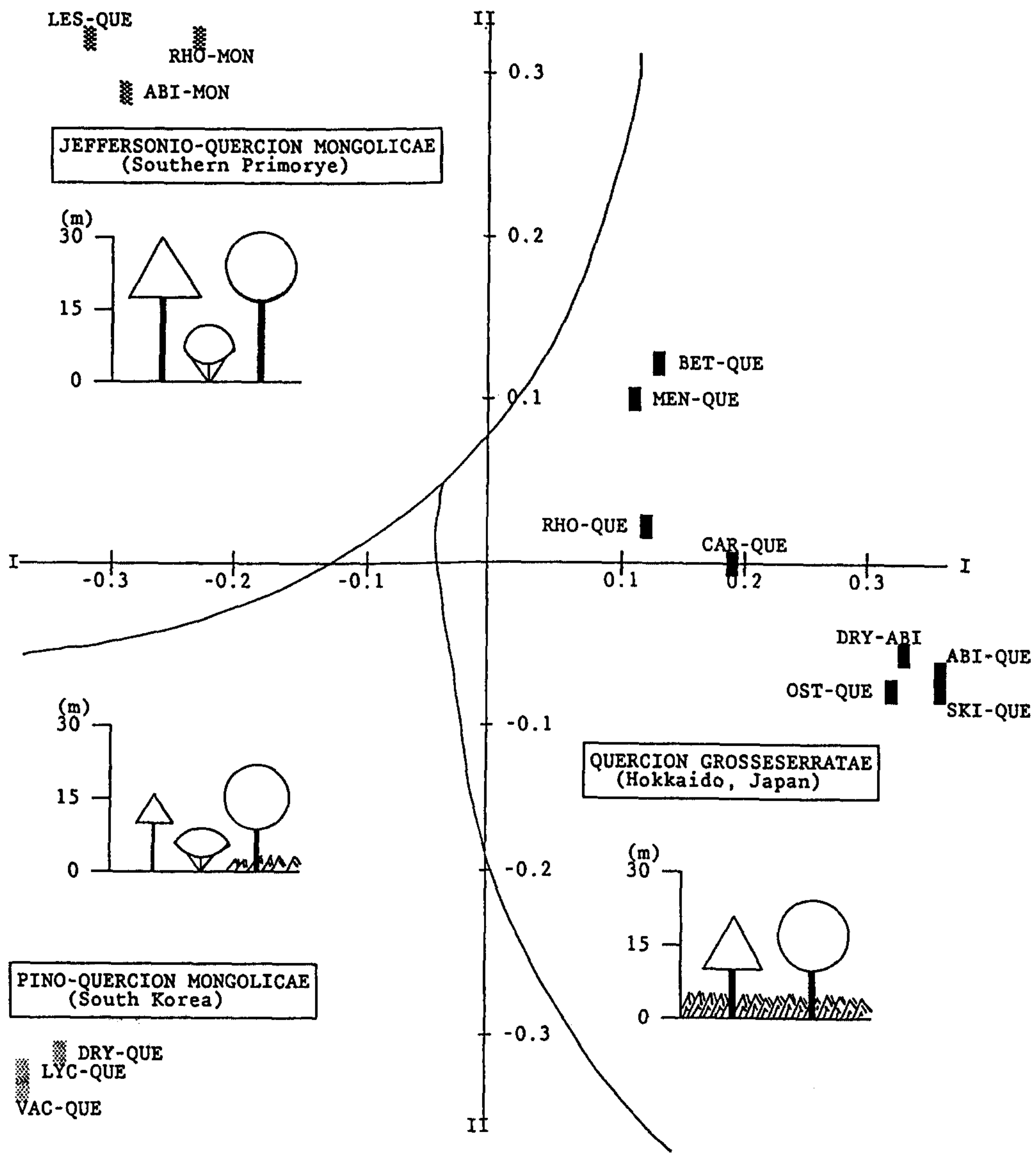

Fig. 5. Ordination and typified scheme of plant communities. Abbreviations correspond to name of plant communities in Table 3.

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).

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

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