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Syntaxonomy and Syngeography of Korean Red Pine (*Pinus densiflora*) Forests in Korea[1]

Young-Moon Chun[2*], Ho-Joon Lee[3], Ichiroku Hayashi[4]

한국 소나무림의 군락분류와 군락지리[1]

전영문[2*] · 이호준[3] · Ichiroku Hayashi[4]

요 약

Z-M방법으로 한국 전역의 소나무림에 대한 식물사회학적 연구를 수행하였다. 소나무림은 크게 1군집, 3군락, 7아군락으로 구분되었다. 한국 소나무림의 분류체계는 다음과 같다.

Rhododendro-Quercetalia mongolicae Kim 1990
Ⅰ: Lindero-Quercion mongolicae Kim 1990 em. Kim 1992
A: *Quercus mongolica-Pinus densiflora* community
A-1: Typical subcommunity
A-2: *Vaccinium koreanum* subcommunity
A-3: *Rhododendron micranthum* subcommunity
B: *Quercus serrata-Pinus densiflora* community
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B-2: *Juniperus rigida* subcommunity
B-3: *Styrax japonica* subcommunity
B-4: *Eurya japonica* subcommunity
C: Saso-Pinetum densiflorae Yim *et al.* 1990
Camellietalia japonicae Oda et Sumata 1966
Ⅱ: Ardisio-Castanopsion Miyawaki *et al.* 1971
D: *Castanopsis cuspidata* var. *sieboldii-Pinus densiflora* community

소나무-신갈나무군락은 한반도 중북부지역의 산지에 주로 분포하였으며, 소나무-졸참나무군락은 한반도 중부와 남부의 저산지와 구릉지에 넓게 나타났다. 소나무-제주조릿대군집은 제주도의 소나무림에서 조사되었다. 그리고 소나무-구실잣밤나무군락은 남서해안과 도서를 포함하는 난온대역에 분포하였다.

주요어 : 분포역, 소나무, 식물사회학, Z-M 방법, 한반도.

ABSTRACT

We carried out a phytosociological study on pine forests in Korea with the method of

1 접수 3월 31일 Received on Mar. 31, 2007
2 Department of Biology, School of Natural Sciences, Sunchon National University, Jeonnam Suncheon(540-742), Korea
3 Department of Biological Sciences, College of Science, Konkuk University, Seoul(143-701), Korea
4 Sugadaira Montane Research Center, University of Tsukuba, Nagano(368-201), Japan
* 교신저자, Corresponding author(ymchun@sunchon.ac.kr)

Zurich-Montpellier School. We collected the data of 252 relevés from 45 sites in the pine forests throughout the Korean Peninsula and its attached islands. The vegetation of the pine forests was classified into one association, three communities and seven subcommunities as follows: A: *Quercus mongolica-Pinus densiflora* community, A-1: Typical subcommunity, A-2: *Vaccinium koreanum* subcommunity, A-3: *Rhododendron micranthum* subcommunity, B: *Quercus serrata-Pinus densiflora* community, B-1: Typical subcommunity, B-2: *Juniperus rigida* subcommunity, B-3: *Styrax japonica* subcommunity, B-4: *Eurya japonica* subcommunity, C: Saso-Pinetum densiflorae Yim *et al.* 1990, and D: *Castanopsis cuspidata* var. *sieboldii-Pinus densiflora* community. The former three communities were integrated into the Lindero-Quercion mongolicae Kim 1990 em. 1992. The *Castanopsis cuspidata* var. *sieboldii-Pinus densiflora* community remained to be studied in future to determine the association. The communities of *Quercus mongolica-Pinus densiflora* community was distributed throughout the montane zone in central-northern part of the Korean Peninsula. *Quercus serrata-Pinus densiflora* community occupied widely in the sub-montane and hilly areas in central and Southern Korean Peninsula. The association of Saso-Pinetum densiflorae was found in Cheju Island. *Castanopsis cuspidata* var. *sieboldii-Pinus densiflora* community were distributed in the warm-temperate zone including islands off the south-west coast of the Peninsula.

KEY WORDS : DISTRIBUTIONAL AREA, KOREAN PENINSULA, PHYTOSOCIOLOGY,* PINUS DENSIFLORA, *ZURICH-MONTPELLIER SCHOOL METHOD.

INTRODUCTION

Pine is distributed throughout almost all the northern hemisphere from the Kamchatka Peninsula at the eastern end of the European Continent to western European margins, such as England, Spain and the Canary Archipelago. The genus *Pinus* contains 111 species, and *Pinus densiflora*, a wide-ranging species, occurs throughout the region spanning Korea, Japan, China and Russia, excluding Manchuria and the Santung Peninsula(Nakai, 1911; Mirov, 1967; Richardson, 1997). In Korea, the pine forests cover the area from Cheju Island(N 33°20′) to Jeungsan, Hambuk province (N 43°20′)(Chung and Lee, 1965; Lee, 1976). They are also found on all the major islands of Japan, apart from Hokkaido, from Yakushima in the southern extremity of Kyushu to Aomori in the northern tip of Honshu (Yoshioka, 1958). These areas span climatic regions ranging from subtropical through temperate to subarctic zones.

Many *Pinus densiflora* stands of the Korean Peninsula are secondary forests: primary forests modified by the effects of human activities from ca. 2000 BP(Jo, 1979; Choi *et al.*, 2005). In this process, deciduous forests dominated by species such as *Quercus mongolica*, have been replaced with pine forests by various human activities, including cultivation, burning, fertilization and fuel collection(Kamada *et al.*, 1991; Rim *et al.*, 1991; Hong, 1998; Lee *et al.*, 2001). However, pine forests are also often observed in exposed, rocky habitats or block fields where they represent the edaphic climax(Chun *et al.*, 2006).

Pine trees have long been used for their scenic properties and timber production in Korea. During the Koryo Dynasty(AD 918-1392) and Chosun Dynasty (AD 1392-1910) they were conserved by law(Chun, 1993). These trees were treated with profound respect as valuable national resources. As a result, pine seedling nurseries and plantations of young trees were promoted, and pine forests grew luxuriantly. However, during the Japanese occupation of Korea(1910-1945), the Korean War(1950-1953) and subsequent periods most of these forests have been destroyed by thoughtless logging for wartime resources, fuel collection and, more recently, by pine gall midges(Lee, 1976; Rim *et al.*, 1991). A number of phytosociological studies on the pine forests in Korea

have been published from the late 1980s onwards. However, these studies were mostly restricted to specific regions or limited study sites in the montane zone(Kim and Yim, 1986; Lee and Lee, 1989; Cho and Hong, 1990; Lee *et al.*, 1995; Bae and Lee, 1999; Yang, 2002). Therefore, to obtain a wider perspective, we have considered the syntaxonomy, distribution and habitat feature of the pine forests throughout the whole of Korea.

MATERIALS AND METHODS

1. Study area

Korea is located in the Far East of the Euro-Asian Continent(Figure 1). The Korean Peninsula extends southwards towards the Japanese Archipelago along the western rim of the Pacific, ranging from about 124 to 132° longitude and 33～43° latitude(Kwon, 1996).

Geologically, the Korean Peninsula is composed of various strata, among which metamorphic, igneous and sedimentary rocks account for about 50%, 30% and 20%, respectively, of the bedrock. The pine forests grow especially well in the areas of Uljin, Bonghwa, Cheongsong and Jeongseon where the underlying rocks are mainly sedimentary or granitic. The forest soil of the Korean Peninsula originates from various kinds of rocks, and the pine stands have adapted accordingly. In particular, the distribution of pine forests of the central/southern higher montane type(Uyeki, 1928) coincide with that of the Brown Forest group of soils, and these stands tend to have strong height growth compared with forests growing on Red, Maroon and Gray Brown Forest soils(K.F.R.I., 1999; Lee, 1998; Lee, 1999).

According to Köppen's climatic criteria, the Korean Peninsula is divided into Cf and Dw zones(Cha *et al.*, 1975). The mean annual temperature of the study areas is about 10～16℃. The mean annual precipitation is about 1,000～1,800mm, and 50～60% of the precipitation falls in the summer season(KMA, 2001).

In terms of vegetation, the coastal area of the southern part of the Korean Peninsula and Cheju Island lie in a warm-temperate forest zone. Kira's warmth and coldness indices(Kira, 1948) of these areas are 108.1～

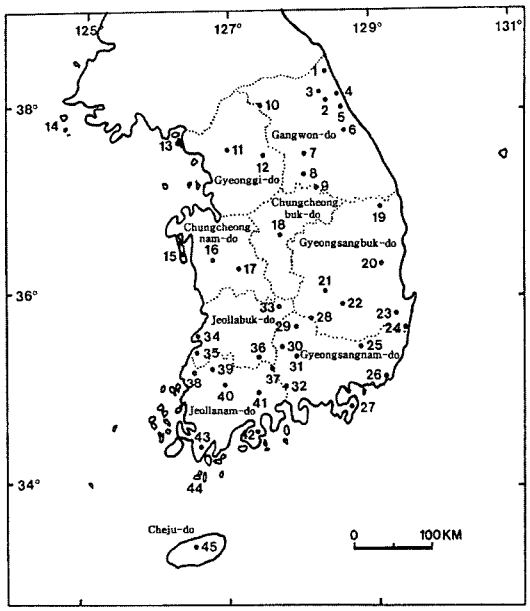

Figure 1. Map showing the study sites

Numerals indicate the following stations and number of quadrat be included in each station: 1. Mt. Noin(383m), Mt. Goseong(179m): 2; 2. Mt. Seorak(1,708m): 24; 3. Mt. Maebong(1,271m): 2; 4. Sokcho: 8; 5. Yangyang: 5; 6. Mt. Odae(1,563m): 9; 7. Mt. Juklim(641m), Mt. Deokgo(705m): 5; 8. Mt. Chiak(1,288m): 6; 9. Mt. Gamakbong(886m), Mt. Yongdu(871m): 2; 10. Mt. Baegun(904m): 4; 11. Mt. Bukhan(837m): 4; 12. Mt. Yongmun(1,157m): 7; 13. Ganghwado Island: 3; 14. Baekryeongdo Island, Daecheongdo Island: 7; 15. Anmyeondo Island: 5; 16. Mt. Chilgab(561m): 4; 17. Mt. Gyeryong(845m): 5; 18. Mt. Songli(1,058m): 5; 19. Uljin: 21; 20. Mt. Juwang(721m): 7; 21. Mt. Geumo (977m): 4; 22. Mt. Palgong(1,192m): 5; 23. Gyeongju (Mt. Nam(262m), Angang): 4; 24. Weolseong: 4; 25. Miryang: 3; 26. Gori: 3; 27. Geojedo Island: 8; 28. Mt. Gaya(1,430m): 7; 29. Geochang: 2; 30. Sancheong: 1; 31. Hamyang: 1; 32. Hadong: 4; 33. Mt. Deokyu(1,614 m): 3; 34. Buan: 5; 35. Gochang, Mt. Gyeongsu(444m), Mt. Soyo(444m): 7; 36. Namweon: 6; 37. Mt. Jiri(1,915 m): 8; 38. Yeonggwang, Mt. Geumjeong(264m): 7; 39. Jangseong, Mt. Bangjang(606m): 5; 40. Mt. Mudeung (1,187m), Hwasun: 5; 41. Suncheon: 3; 42. Mt. Palryeong(609m): 4; 43. Mt. Duryun(703m): 3; 44. Bogildo Island: 6; 45. Mt. Halla(1,950m): 9.

126.1℃·month and -8.0~0.0℃·month, respectively, while the inland area is in a cool temperate deciduous broad-leaved forest zone(Yim and Kira, 1975), where the warmth and coldness indices are 85.9~114.2℃·month and -27.6~-12.8℃·month, respectively.

The study sites included montane areas, hills, islands and coastal regions in Korea. The fieldwork was carried out in the 45 selected sites using 252 relevés from May 1994 to August 2002 (Figure 1).

2. Methods

The fieldwork was carried out following the phytosociological method of Braun-Blanquet(1964). The coverage and abundance in each plot were determined for all herbaceous plants, shrubs(0.8 to 2m), understory trees(2 to 8m), and overstory trees (>8m). Stems of the understory and overstory species were counted for more than 2cm diameter at breast height (DBH) in each quadrat. Plot sizes were based on stand heights, and varied from 10×10m to 25×25m. The data in the synthesis and association tables were processed according to hand-sorting method of Mueller-Dombois and Ellenberg(1974). while botanical nomenclature follows Ohwi(1978), Lee(1985) and Park(1995).

Contributions of species in classified units were ranked by relative values of the net contribution degree (r-NCD). The NCD and r-NCD values were obtained from functions considering both coverage and frequency of species for the respective units(Kim and Manyko, 1994), as follows:

$NCD_i = C_i/N \times n_i/N (C_{min} \leq NCD \leq C_{max})$

where C_i is the coverage of species $_i$, n_i is the number of relevés with the species $_i$, and N is the total number of relevés in a unit.

$r\text{-}NCD_i = NCD_i/NCD_{max} \times 100$

NCD_i: NCD value of i species of certain species in a unit

NCD_{max}: maximum NCD value of certain species in a unit

RESULTS AND DISCUSSION

1. Classification

The *Pinus densiflora* forests in Korea were classified according to the phytosociological system shown in Table 1. Site characteristics for each relevé within communities of pine forests are presented in Table 2, 3 and 4. The pine forests in Korea were classified one association, three communities and seven subassociations as follows:

Rhododendro-Quercetalia mongolicae Kim 1990

Ⅰ: Lindero-Quercion mongolicae Kim 1990 em. Kim 1992

A: *Quercus mongolica-Pinus densiflora* community

A-1: Typical subcommunity

A-2: *Vaccinium koreanum* subcommunity

A-3: *Rhododendron micranthum* subcommunity

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D: *Castanopsis cuspidata* var. *sieboldii-Pinus densiflora community*

The most frequent species in the *Pinus densiflora* forests of Korea were as follows: *Quercus serrata, Lindera obtusiloba, Rhododendron mucronulatum, Spodiopogon sibiricus, Rhus trichocarpa, Artemisia keiskeana, Smilax china, Atractylodes japonica, Carex humilis, Q. mongolica, Aster scaber, Prunus sargentii, Q. variabilis, Lespedeza maximowiczii, Pteridium aquilinum* var. *latiusculum, Disporum smilacinum* and *Pyrola japonica.*

2. Characteristics of orders and alliances

Pinus densiflora occurs mainly in the deciduous broad-leaved forest zones, from temperate to subtropic regions. The pine stands are secondary forests in a successional stage that has been maintained by human activities. The area of its distribution has therefore enlarged beyond its edaphic climax region(Lee, 1976) and the forests have developed under a range of edaphic and topographic conditions. Because of their diversity, the vegetation units of the pine forests have not been

Table 1. Synthesis vegetation table of *Pinus densiflora* forests in Korea

Rhododendro-Quercetalia mongolicae Kim 1990
I: Lindero-Quercion mongolicae Kim J.-W. 1990 em. Kim 1992
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Camellietalia japonicae Oda et Sumata 1966
II: Ardisio-Castanopsion Miyawaki *et al.* 1971
D: *Castanopsis cuspidata* var. *sieboldii-Pinus densiflora* community

Vegetation units:	I								II
	A			B				C	D
	A-1	A-2	A-3	B-1	B-2	B-3	B-4		
Number of relevé:	42	9	10	61	35	57	23	9	6
Average number of species:	29.9	29.2	25.4	39.2	32.9	41.1	45.2	26.8	25.2
Differential species of *Quercus mongolica-Pinus densiflora* community									
Quercus mongolica	V(+-5)	V(1-4)	IV(+-5)	IV(+-3)	II(+-2)	II(+-3)	I(+)	·	·
Chrysanthemum zawadskii	II(+-2)	IV(+-2)	·	I(+-1)	r	·	·	·	·
Viola orientalis	II(+-2)	II(+)	III(+)	I(+-2)	I(+)	r	·	·	·
Differential species of *Vaccinium koreanum* subcommunity									
Vaccinium koreanum	·	V(+-2)	·	·	·	·	·	·	·
Differential species of *Rhododendron micranthum* subcommunity									
Rhododendron micranthum	·	·	V(+-3)	r	·	·	·	·	·
Differential species of *Quercus serrata-Pinus densiflora* community									
Quercus serrata	III(+-1)	II(+)	IV(+)	V(+-4)	V(+-3)	V(+-4)	V(+-3)	·	II(+-1)
Carex lanceolata	I(+-1)	I(+)	I(+-1)	II(+-4)	III(+-2)	III(+-3)	III(+-2)	·	·
Zanthoxylum schinifolium	II(+)	·	II(+)	II(+-2)	II(+)	III(+-1)	III(+)	I(+)	·
Smilax nipponica	II(+-1)	·	·	III(+-2)	I(+-1)	III(+-1)	I(+)	·	·
Calamagrostis arundinacea	II(+-1)	I(+)	I(1)	III(+-1)	II(+-1)	III(+-2)	I(+)	·	·
Viburnum erosum	I(+)	·	·	I(+-2)	II(+-1)	IV(+-3)	III(+-2)	·	IV(+)
Oplismenus undulatifolius	I(+-1)	·	I(+)	II(+-2)	II(+-1)	III(+-2)	II(+-2)	·	·
Corylus heterophylla var. *thunbergii*	I(+)	I(+)	·	II(+)	I(+-2)	III(+-1)	III(+)	·	·
Paederia scandens	r	·	·	r	II(+)	II(+-1)	II(+-1)	·	V(+)
Lindera glauca	·	·	·	I(+)	II(+-1)	II(+-1)	III(+-1)	·	·
Isodon inflexus	r	·	I(+)	I(+)	I(+)	III(+-1)	I(+)	·	·
Celastrus orbiculatus	r	I(+)	·	I(+)	I(+)	II(+)	I(+)	·	·
Quercus aliena	·	·	I(+)	I(+-2)	II(+-3)	I(+-2)	II(+-3)	·	·
Rhus chinensis	I(+-1)	·	I(+)	I(+-2)	I(+-1)	II(+-2)	I(+)	·	·
Platycarya strobilacea	·	·	·	r	I(+)	II(+-2)	III(+-1)	·	·
Quercus dentata	I(+)	I(+)	·	I(+-2)	I(+-3)	I(+-2)	I(+-1)	·	·
Differential species of *Juniperus rigida* subcommunity									
Juniperus rigida	I(+)	·	I(+)	I(+)	V(+-3)	II(+-1)	II(+-1)	·	I(+)
Rhododendron yedoense var. *poukhanense*	·	·	I(+)	r	III(+-4)	I(+)	II(+-3)	I(+)	·
Differential species of *Styrax japonica* subcommunity									
Styrax japonica	I(+-1)	·	·	I(+-1)	III(+-1)	V(+-5)	IV(+-4)	II(+-3)	·
Quercus variabilis	III(+-2)	I(+)	IV(+-4)	II(+-3)	II(+-3)	IV(+-4)	II(+-1)	·	·
Differential species of *Eurya japonica* subcommunity									
Eurya japonica	·	·	·	·	·	·	V(+-4)	·	V(+-3)
Trachelospermum asiaticum var. *intermedium*	·	·	·	·	I(+)	·	III(+-4)	·	V(+-1)
Character and differential species of Saso-Pinetum densiflorae									
Ilex crenata	·	·	·	·	r	r	I(+)	IV(+-1)	·
Sasa quelpaertensis	·	·	·	·	·	·	·	V(5)	·
Quercus mongolica var. *grosseserrata*	·	·	·	·	·	·	·	V(+-2)	·
Asarum maculatum	·	·	·	r	·	·	·	IV(+-1)	·
Prunus maximowiczii	·	·	·	r	·	·	·	IV(+-1)	·
Schizophragma hydrangeoides	·	·	·	·	·	·	·	IV(+-1)	·
Mitchella undulata	·	·	·	·	·	r	·	III(+-1)	·
Daphniphyllum macropodum	·	·	·	·	·	·	·	III(+-4)	·
Character and differential species of Lindero-Quercion mongolicae and Rhododendro-Quercetalia mongolicae									
Lindera obtusiloba	IV(+-2)	V(+-1)	III(+-1)	V(+-2)	II(+-1)	IV(+-3)	III(+-2)	I(+)	I(+)
Rhus trichocarpa	IV(+-2)	IV(+-3)	III(+)	IV(+-3)	IV(+-2)	IV(+-2)	III(+-2)	·	II(+)
Lespedeza maximowiczii	II(+-2)	II(+)	I(+)	IV(+-3)	II(+-1)	IV(+-1)	III(+-2)	·	·
Fraxinus sieboldiana	II(1-4)	IV(1-2)	V(+-2)	II(+-3)	III(+-3)	III(+-4)	III(+-3)	·	I(+)
Fraxinus rhynchophylla	III(+-2)	II(+)	I(+)	IV(+-3)	I(+)	III(+-2)	I(+)	·	·
Rhododendron schlippenbachii	III(+-3)	V(+-4)	II(1)	III(+-4)	II(+-3)	II(+-5)	I(+-2)	·	·
Lespedeza bicolor	II(+-1)	II(+-1)	III(+-1)	II(+-1)	III(+-1)	II(+-2)	II(+-2)	·	·
Styrax obassia	III(+-3)	III(+-1)	III(+-1)	III(+-4)	I(+)	II(+-1)	I(+)	·	·
Acer pseudo-sieboldianum	II(+-3)	IV(+)	I(+)	III(+-4)	I(+-1)	II(+)	II(+-3)	IV(+)	·
Carpinus laxiflora	II(+-1)	·	·	II(+-5)	r	II(+-3)	II(+-3)	IV(+-4)	·
Weigela subsessilis	I(+-3)	II(+)	I(+)	I(+-3)	r	I(+-1)	I(+-1)	II(+)	·
Ligustrum obtusifolium	·	I(+)	·	I(+)	I(+-1)	II(+)	II(+-1)	III(+)	·
Carex ciliato-marginata	r	I(1)	I(+)	r	I(+-1)	II(+-2)	II(+-3)	II(+)	·

Table 1. (Continued)

Differential species of *Castanopsis cuspidata* var. *sieboldii*-*Pinus densiflora* community									
Quercus myrsinaefolia	.	.	.	.	.	.	.	.	V (+-1)
Castanopsis cuspidata var. *sieboldii*	.	.	.	.	.	.	.	.	V (1-3)
Raphiolepis umbellata	.	.	.	.	.	.	r	.	IV (+)
Character and differential species of Ardisio-Castanopsietum sieboldii									
Cymbidium goeringii	.	.	.	r	I (+-2)	II (+-1)	III (+-1)	.	V (+)
Ophiopogon japonicus	.	.	.	.	r	I (+)	I (+)	I (+)	V (+)
Ardisia japonica	.	.	.	.	.	.	.	.	IV (+-1)
Kadsura japonica	r	.	.	.	.	.	I (+)	.	I (+)
Stauntonia hexaphylla	.	.	.	.	.	.	I (+)	.	III (+)
Quercus salicina	.	.	.	.	.	.	.	.	III (1-2)
Character species of Camellietalia japonicae and Camellietea japonicae									
Ligustrum japonicum	.	.	.	.	r	.	II (+-1)	.	V (+)
Camellia japonica	.	.	.	.	.	.	II (+)	.	V (1-3)
Neolitsea sericea	.	.	.	.	.	.	I (+)	.	V (+)
Quercus acuta	.	.	.	.	.	.	.	.	III (+-1)
Companions									
Pinus densiflora	V (4-5)	V (5)	V (4-5)	V (4-5)	V (4-5)	V (4-5)	V (4-5)	V (5)	V (4-5)
Rhododendron mucronulatum	IV (+-3)	V (+-3)	IV (1-3)	IV (+-5)	V (+-5)	III (+-3)	III (+-3)	II (+)	II (+)
Spodiopogon sibiricus	V (+-4)	IV (+-1)	V (1-2)	IV (+-3)	IV (+-3)	IV (+-2)	IV (+-3)	II (+-2)	.	.
Artemisia keiskeana	IV (+-2)	IV (+-2)	IV (+-1)	IV (+-2)	IV (+-2)	III (+-1)	II (+-2)	.	.
Smilax china	I (+)	I (+)	I (+)	III (+-1)	IV (+-2)	V (+-2)	IV (+-2)	V (+)	IV (+-1)
Atractylodes japonica	IV (+-1)	IV (+)	IV (+-1)	III (+-1)	IV (+-1)	IV (+-1)	III (+)	.	.
Carex humilis	IV (+-3)	V (+-2)	IV (1-2)	IV (+-3)	III (+-3)	III (+-2)	II (+-4)	.	I (+)
Aster scaber	III (+-1)	III (+-1)	IV (+-1)	III (+-1)	III (+-1)	IV (+-1)	IV (+-1)	.	II (+)
Prunus sarsentii	III (+-1)	III (+)	.	III (+-3)	II (+-2)	IV (+-2)	IV (+-1)	I (+)	.
Pteridium aquilinum var. *latiusculum*	II (+-1)	I (+)	I (+)	III (+-2)	III (+-2)	III (+-2)	III (+-2)	II (+)	III (+)
Pyrola japonica	III (+-1)	II (+-1)	I (+)	III (+-1)	III (+-2)	III (+-1)	III (+-2)	.	IV (+)
Polygonatum odoratum var. *pluriflorum*	IV (+-2)	IV (+-1)	I (+)	III (+-1)	II (+-1)	II (+-1)	I (+-1)	.	II (+)
Symplocos chinensis for. *pilosa*	II (+-1)	II (+)	I (+)	III (+-1)	I (+)	III (+-1)	III (+-1)	.	III (+)
Disporum smilacinum	I (+-3)	II (+-1)	.	III (+-4)	I (+-4)	III (+-4)	III (+-5)	IV (+)	V (+)
Stephanandra incisa	I (+-2)	.	I (+)	III (+-3)	II (+-1)	III (+-3)	III (+-3)	.	.
Sorbus alnifolia	II (+-1)	I (+)	I (+)	II (+-1)	I (+-1)	III (+-3)	II (+-1)	II (+)	II (+)
Parthenocissus tricuspidata	I (+-2)	.	.	III (+-2)	II (+-1)	III (+-2)	I (+)	II (+-1)	.
Patrinia villosa	II (+-1)	II (+)	IV (+-1)	II (+-1)	II (+-1)	II (+)	I (+)	.	.
Smilax sieboldii	I (+)	II (+)	.	II (+-1)	II (+-1)	II (+-1)	II (+)	II (+)	.
Castanea crenata	r	I (+)	I (+)	II (+-2)	II (+-3)	III (+-1)	I (+)	.	I (+)
Peucedanum terebinthaceum	III (+-1)	IV (+)	III (+)	II (+-1)	I (+)	I (+)	I (+)	.	.
Cocculus trilobus	I (+)	I (+)	I (+)	I (+)	II (+-1)	III (+-1)	II (+-1)	.	.
Potentilla freyniana	II (+-1)	I (+)	III (+-1)	II (+-1)	II (+-2)	I (+-1)	I (+)	.	.
Lindera erythrocarpa	r	.	.	I (+-1)	I (+-1)	II (+-3)	II (+-1)	III (+-3)	I (+)
Solidago virga-aurea var. *asiatica*	I (+)	.	II (+-1)	II (+-1)	I (+)	II (+)	II (+)	.	.
Callicarpa japonica	I (+)	.	I (+)	II (+-1)	I (+)	II (+-1)	II (+-2)	.	.
Carex siderosticta	I (+-1)	.	.	III (+-2)	I (+-3)	I (+-1)	II (+-2)	.	.
Melica onoei	I (+-3)	II (+-1)	.	I (+-1)	II (+-1)	II (+-1)	II (+-1)	.	I (+)
Lespedeza cyrtobotrya	II (+-1)	II (1)	II (+)	I (+-1)	I (+-3)	r	I (+-1)	.	.
Melampyrum roseum	II (+-3)	I (+)	.	I (+-3)	I (+)	I (+)	I (+-1)	I (+-1)	.
Rubus crataegifolius	II (+-1)	II (+)	.	II (+-1)	I (+)	I (+-1)	I (+-2)	.	.
Vaccinium oldhami	.	.	.	r	II (+-3)	II (+-2)	II (+-2)	II (+)	II (+)
Dioscorea japonica	r	.	.	I (+-1)	I (+)	II (+)	I (+)	.	I (+)
Syneilesis palmata	I (+)	.	I (+)	I (+-1)	r	I (+)	II (+)	.	.
Kalopanax pictus	I (+)	.	.	II (+)	I (+)	I (+-1)	I (+)	III (+-1)	.
Rosa multiflora	r	.	I (+)	I (+)	I (+-1)	I (+-1)	I (+-1)	I (+)	.
Viola rossii	I (+-1)	II (+)	I (+)	I (+-1)	r	I (+-1)	I (+-2)	I (+)	.
Chrysanthemum zawadskii var. *latilobum*	I (+-2)	II (+)	III (+-1)	I (+-2)	II (+-1)	r	r	.	.
Platycodon grandiflorum	I (+)	.	II (+)	I (+)	II (+)	I (+)	.	.	.
Hosta longipes	I (+)	I (+)	.	I (+-1)	I (+)	I (+-1)	I (+-1)	II (+-1)	.
Indigofera kirilowi	r	I (+)	.	r	II (+-2)	II (+-2)	I (+-2)	.	II (+)
Vitis amurensis	I (+)	.	.	I (+-1)	r	I (+)	I (+)	.	.
Viola dissecta var. *chaerophylloides*	I (+-1)	I (+)	.	I (+-1)	r	I (+-1)	I (+-2)	.	.
Miscanthus sinensis var. *purpurascens*	r	I (+)	.	I (+-1)	II (+-2)	I (+-2)	II (+-3)	.	.
Maackia amurensis	I (+)	II (+)	.	I (+)	I (+-1)	I (+-2)	I (+)	II (+)	.
Ampelopsis brevipedunculata var. *heterophylla*	I (+)	I (+)	.	I (+)	r	II (+)	I (+)	I (+)	.
Pueraria thunbergiana	r	.	I (+)	I (+)	I (+)	II (+)	I (+)	.	I (+)
Hemerocallis fulva	I (+)	.	.	I (+-1)	I (+)	I (+)	I (+)	.	.
Robinia pseudo-acacia	r	.	I (+)	I (+-1)	II (+-2)	I (+-1)	.	.	.
Lonicera japonica	.	.	I (+)	I (+)	I (+)	I (+)	I (+)	.	I (+)
Lysimachia clethroides	I (+-1)	I (+)	I (+)	I (+)	I (+-1)	I (+)	I (+)	.	.
Lonicera praeflorens	I (+)	.	.	I (+)	.	I (+)	I (+)	.	II (+)
Potentilla fragarioides var. *major*	r	.	I (+)	I (+)	I (+-1)	I (+)	I (+-1)	.	.
Clematis mandshurica	I (+)	.	I (+)	I (+)	I (+)	I (+)	I (+)	.	.
Astilbe chinensis var. *davidii*	I (+)	II (+)	I (+)	I (+)	r	I (+)	r	.	.

Table 2. Site characteristics for each relevé within the *Quercus mongolica-Pinus densiflora* community

Vegetation units	A-1																													
Serial No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Relevé No.	11	13	17	22	24	25	26	27	28	36	37	41	50	56	59	74	108	110	256	271	273	275	276	282	283	286	287	289	331	332
Station no.	8	8	7	7	7	12	12	12	9	3	3	10	2	2	2	2	11	11	37	2	2	2	2	2	2	2	2	2	17	17
Altitude (m)	560	625	620	390	430	470	650	700	510	540	590	440	35	205	176	50	490	590	940	700	500	490	460	350	505	335	325	855	340	420
Slope aspect	SW80	NW60	SW10	NW7	NW60	SE62	SE38	SE13	SW32	SW25	SW70	S	SW70	S	SW20	NW56	SE53	S	SE66	SW76	SW34	SW74	W	SW54	SW46	SW48	NE26	SW10	SW16	SE24
Slope degree (°)	24	8	24	23	20	35	30	35	29	15	30	43	30	30	10	28	18	8	35	40	32	24	15	32	18	36	20	42	33	23
Topography	M	M	U	U	L	M	M	M	M	L	L	L	H	H	H	H	R	M	U	R	R	R	R	R	R	M	L	U	M	T
Quadrat size (m^2)	400	225	225	225	225	225	225	400	400	225	400	100	225	100	100	225	100	100	400	225	400	100	100	100	100	225	225	400	225	100
T1 - Height (m)	17	14	14	11	13	14	15	17	17	18	20	9	15	10	8	14	·	10	18	12	20	8	8	9	·	13	13	17	12	10
Coverage (%)	60	80	90	75	90	90	90	80	80	85	85	75	80	95	90	95	·	90	90	90	80	90	90	70	·	95	95	85	95	95
T2 - Height (m)	7	5	3	4	6	3.5	5	6	6	7	8	5	5	4	5	·	4	4	8	5	6	·	5	4	5	6	5	7	5	5
Coverage (%)	80	50	5	20	40	10	25	25	60	15	50	3	10	5	10	·	80	25	70	15	80	·	15	30	85	20	40	60	15	10
S - Height (m)	1.8	1.5	1.5	2	1.7	1.5	1.6	1.8	1.2	1.5	2.3	2	2	2	2	2	1.2	1.5	2	1.3	1.5	·	1.5	1.2	1.2	2	1.6	1.8	2	1.6
Coverage (%)	35	60	15	80	20	20	35	30	15	20	40	40	50	40	80	70	45	55	15	50	70	·	2	10	35	60	65	35	65	60
H - Height (m)	0.7	0.6	0.6	0.5	0.5	0.3	0.4	0.3	0.3	1	0.7	1	0.8	0.5	0.5	0.8	0.4	0.3	0.5	0.3	0.4	0.5	0.6	0.4	0.3	0.6	0.5	0.4	0.5	0.4
Coverage (%)	25	15	70	40	15	40	30	20	30	70	50	20	70	60	60	40	10	15	35	60	45	60	40	40	20	40	40	20	70	35
No. of species	44	50	48	34	32	54	28	27	48	21	27	9	37	18	34	18	26	29	44	37	36	18	15	22	21	25	38	25	45	22

	A-1												A-2												A-3											
	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61
	333	335	336	338	340	343	348	357	358	359	385	389	274	290	308	354	366	368	369	384	386	126	360	361	362	364	373	374	375	377	379
	17	20	20	20	20	20	6	6	6	6	22	16	2	2	18	6	19	19	19	22	22	19	19	19	19	19	19	19	19	19	19
	380	430	405	560	450	445	340	760	670	810	520	420	600	810	420	620	420	640	740	700	820	90	330	350	380	330	240	290	260	310	280
	NE34	NW72	S	SW34	SW58	W	SE10	SW36	SW74	SW34	NW75	W	NW50	SW54	NE28	SW66	NW26	W	NE14	SE86	SW80	SW78	NW80	NE68	SW64	S	NW58	SW58	NW72	SW54	NW54
	35	39	36	38	34	28	15	13	37	29	30	28	29	20	30	36	30	40	25	30	30	32	35	38	35	45	32	32	37	32	39
	U	U	L	U	M	U	R	U	L	L	L	M	U	T	M	M	L	U	U	M	U	H	M	L	U	M	U	M	L	R	U
	225	225	225	225	225	100	100	625	625	625	225	225	400	100	625	225	625	225	225	100	100	225	225	400	100	100	225	225	225	400	225
	12	15	14	15	12	10	7	26	23	23	14	13	20	10	22	12	22	15	16	11	9	14	12	17	8	9	13	15	15	18	12
	95	55	95	75	75	95	70	95	95	90	90	95	75	75	95	90	90	90	95	90	85	85	75	80	70	85	90	90	95	95	90
	3.5	7	7	7	5	5	4	7	8	8	6	5	6	4	4	5	9	7	8	5	5	6	5	8	3	5	4	7	7	7	4.5
	70	50	40	30	15	5	5	75	85	85	50	30	40	40	85	55	80	20	40	30	10	40	40	80	10	15	50	60	85	20	75
	1.5	1.7	2.5	1.6	1.5	1.4	1	2.2	2	1.3	3	2.2	1.6	1.1	1.8	1.3	2	2	1.8	2	2.5	2	1.5	1.8	1.3	1.5	1.5	1.6	1.5	1.5	1.6
	60	15	75	70	45	40	10	65	25	30	70	40	40	60	65	70	90	90	80	40	70	30	50	50	30	25	80	45	50	30	70
	0.3	0.6	0.5	0.5	0.5	0.3	0.4	1.1	0.3	0.6	0.3	0.7	0.5	0.4	0.6	0.4	0.6	0.7	0.5	0.7	0.5	0.5	0.6	0.6	0.5	0.4	0.5	0.6	0.5	0.7	0.5
	20	65	45	40	60	20	65	95	15	75	50	60	70	45	50	30	80	40	70	80	5	30	35	30	25	10	35	25	55	70	15
	27	27	23	23	21	20	23	19	50	30	19	43	27	24	38	23	37	22	34	46	12	36	24	48	17	16	26	18	27	23	19

* Topography: H: hillside, L: low part of slope, M: middle part of slope, R: ridge, T: top, U: upper part of slope.

Table 3. Site characteristics for each relevé within *Quercus serrata-Pinus densiflora* community

Vegetation units	B-1																													
Serial No.	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	
Releve No.	330	44	217	310	278	220	372	231	307	46	319	3	224	226	311	9	12	66	79	31	45	241	29	134	243	293	349	32	280	
Station no.	17	4	21	18	2	33	19	36	18	4	14	8	12	12	18	8	8	5	5	1	4	28	9	24	28	2	6	1	2	
Altitude (m)	260	115	350	360	300	810	220	250	390	95	70	280	350	360	370	400	520	90	80	90	90	520	470	85	500	330	400	60	250	
Slope aspect	S	SW20	SE25	NW50	-	SW42	SE56	NW78	S	SE40	NW20	SE64	SE40	SW50	NW66	SW62	SE16	NW36	SE10	NE50	NE50	SW16	SE29	SE32	N	-	NW50	SE20	-	
Slope degree (°)	31	5	18	6	-	30	23	32	26	20	14	26	30	37	20	10	23	21	16	20	20	25	10	5	37	-	25	20	-	
Topography	V	H	M	L	F	U	H	M	L	H	H	L	U	U	L	L	L	H	H	H	H	L	L	H	V	F	V	H	F	
Quadrat size (m^2)	225	225	225	625	400	400	625	225	625	225	100	400	400	225	625	400	225	400	100	225	225	400	225	100	400	400	400	225	225	
T1 - Height (m)	15	15	14	26	18	20	24	12	24	15	11	18	16	15	25	20	14	22	9	15	15	18	11	10	20	17	20	12	16	
Coverage (%)	95	85	70	90	90	85	95	90	95	85	95	85	80	85	95	80	80	90	90	80	80	90	80	95	85	95	80	90	95	
T2 - Height (m)	7	6	3	9	9	5	7	3.5	7	6	5	4	6	6	9	7	6	6	5	5	5	8	4	6	4.5	4	7	·	5	
Coverage (%)	60	5	40	95	85	55	95	30	95	20	90	5	90	80	95	70	60	20	25	50	50	65	20	25	80	5	60	·	15	
S - Height (m)	1.8	2	1.6	2	2.5	1.5	2.2	2	1.8	2	1.8	3	2.2	1.8	2	2	1.8	2	2	2	2	2	1.6	1.8	1.8	1.6	2	2	1.5	
Coverage (%)	45	70	40	80	45	35	30	70	15	50	65	80	10	25	30	35	70	25	50	50	50	40	40	75	60	70	45	80	30	
H - Height (m)	0.5	0.8	0.4	0.5	0.7	0.4	0.6	0.3	0.3	0.8	0.3	0.8	0.3	0.3	0.5	0.8	0.7	0.6	0.8	0.8	0.8	0.3	0.3	0.8	0.4	0.6	1	0.7	0.7	
Coverage (%)	25	70	10	30	25	40	35	20	85	80	10	50	10	10	15	60	30	40	30	80	80	20	70	70	20	60	35	40	25	
Number of species	45	64	39	52	64	43	55	42	49	43	39	60	41	32	37	41	52	44	41	46	41	45	42	27	38	55	37	34	52	

	B-1																													
30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	
70	223	49	228	229	269	225	48	292	39	240	244	353	5	84	15	124	133	337	107	296	71	288	294	38	371	60	219	242	192	
5	12	4	25	25	2	12	4	2	10	28	28	6	8	5	7	19	24	20	11	2	5	2	2	10	19	4	33	28	40	
60	360	45	360	330	420	340	25	300	290	560	640	200	600	120	625	100	15	390	340	500	160	550	390	680	210	185	820	480	230	
SE66	SW56	NW25	SE24	SE44	NE34	NE15	NW40	NW60	SW62	NW74	S	-	SE40	SW60	SE42	NE30	SE78	SW36	SE61	-	NW60	SW42	NW78	S	S	SE65	NW40	NE70	N	
24	25	20	28	32	5	25	25	6	32	17	30	-	15	13	18	32	18	40	28	-	15	16	35	25	24	30	31	33	35	
H	M	H	U	M	F	U	H	F	L	L	L	F	M	H	U	H	H	L	U	F	H	L	M	U	L	H	U	V	H	
400	400	225	225	225	200	300	225	225	225	400	400	225	400	100	225	400	225	225	100	225	225	625	225	225	225	225	400	400	400	
20	16	20	13	13	16	15	14	13	15	19	18	14	18	10	15	17	13	15	·	12	17	24	16	15	15	12	21	20	17	
80	75	90	95	85	90	85	90	90	95	95	95	85	90	80	95	85	75	90	·	85	90	90	90	95	85	80	95	95	85	
6	7	8	3.5	4	9	5	5	7	7	6	5	4	9	6	3	6	4	5	7.5	5	5	9	6	7	6	·	12	6	4	
40	95	40	75	5	95	95	20	5	40	40	85	10	50	30	15	20	20	15	90	35	40	95	40	40	90	·	70	30	60	
1.8	2	2	1.5	1.4	2.5	1.6	2	1.5	2	2	1.8	1.8	2	1.8	1.5	2	1.5	2	1.5	1.5	2.2	3	1.8	2	1.5	2	1.5	2.2	1.3	
50	20	50	35	45	30	25	50	25	50	70	45	65	60	40	40	30	95	55	60	30	60	70	60	15	35	70	80	90	80	
0.8	0.3	0.7	0.3	0.4	0.7	0.3	0.8	0.4	0.5	0.4	0.3	1	0.8	0.8	0.8	0.3	0.5	0.5	0.3	0.8	0.7	0.7	0.5	0.8	0.5	0.7	0.4	0.4	0.3	
20	5	60	20	25	35	30	80	60	20	20	10	85	80	50	80	65	50	65	10	90	45	35	40	20	15	50	15	25	30	
24	44	51	31	36	49	46	41	41	34	31	30	48	67	25	55	27	26	23	23	54	22	46	26	31	19	29	29	28	8	

Vegetation units	B-1	B-2																												
Serial No.	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88
Releve No.	125	40	245	341	109	117	129	246	309	136	153	161	207	263	118	120	137	150	163	209	232	233	234	392	90	164	249	380	191
Station no.	19	10	28	20	11	19	19	28	18	24	38	35	23	37	19	19	24	38	35	23	36	36	36	16	4	35	37	22	40
Altitude (m)	90	720	620	315	540	200	110	480	380	60	20	80	120	540	140	90	60	20	250	110	230	280	350	250	100	90	300	200	240
Slope aspect	NE10	NW70	SE15	S	SE23	NE28	NW32	SW22	S	SW54	SE50	SE6	NE76	E	SW84	NE60	SE70	SE56	SW72	S	NE14	SW20	NW46	SW40	E	SW22	SW28	SW70	NE37
Slope degree (°)	28	40	36	33	5	27	17	33	37	24	25	26	21	32	36	10	31	22	28	12	19	36	37	38	25	16	36	15	5
Topography	H	U	R	U	U	M	H	L	U	H	H	L	L	M	H	H	H	H	M	M	U	U	U	L	H	L	M	M	L
Quadrat size (m^2)	225	225	225	100	100	225	100	400	625	100	100	225	225	100	225	225	100	225	100	225	225	100	225	100	225	225	100	100	400
T1 - Height (m)	15	15	13	7	·	16	10	18	24	8	12	15	12	9	15	14	9	14	·	11	12	10	12	9	15	15	10	12	17
Coverage (%)	85	75	80	60	·	85	90	95	95	95	95	90	75	95	75	85	90	95	·	75	85	90	90	95	85	95	90	90	90
T2 - Height (m)	8	·	–	3	4.5	8	4	4	6	3	5	6	4	4.5	6	5	5	5	8	4	3.5	3.5	3.3	6	5	7	5	5	5
Coverage (%)	40	·	–	5	75	50	60	2	50	20	20	30	5	10	30	40	30	5	95	15	5	5	10	30	40	90	10	30	25
S - Height (m)	2	2.5	1.4	1.5	1.3	2	1.6	1.5	1.7	1.5	2	2	1.8	1.5	2	2	2	2	2	1.5	1.5	1.2	1.4	1.8	2	2	2	1.5	1.7
Coverage (%)	80	60	40	30	35	30	80	90	60	85	75	45	65	80	60	40	80	80	10	60	90	30	60	70	60	40	40	30	60
H - Height (m)	0.3	0.8	0.4	0.5	0.4	0.8	0.4	0.4	0.5	0.8	0.8	0.8	0.4	0.5	0.8	0.8	0.8	0.7	1	0.5	0.3	0.3	0.3	0.6	0.8	0.5	0.3	0.7	0.5
Coverage (%)	50	20	25	20	15	80	70	20	40	85	95	35	35	15	70	60	90	90	5	50	20	10	25	60	40	5	10	30	50
Number of species	27	20	25	11	29	32	21	26	35	25	25	25	23	29	19	29	28	26	23	33	26	24	29	28	42	42	29	22	65

	B-2							B-3																						
	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118
	141	236	200	218	199	216	166	239	211	214	326	213	221	193	206	260	268	253	156	158	159	160	165	201	230	266	318	322	334	162
	26	36	41	21	41	21	35	36	34	34	14	34	33	40	23	37	37	30	39	39	39	35	35	41	25	37	14	14	17	35
	90	320	250	320	270	330	330	290	230	160	30	170	760	260	290	320	760	320	330	370	455	395	215	300	260	410	60	80	280	135
	SW30	S	SW40	SW26	NE14	SW24	SW40	NW66	S	S	NW72	S	SW26	S	SW76	SE50	S	SE48	SW70	SE3	SW28	SE40	SW60	SW56	SE36	NW22	S	NE72	SW44	SW36
	18	32	24	29	14	27	18	26	27	26	10	19	18	21	15	10	12	33	26	25	32	27	20	12	12	12	21	13	26	18
	H	L	L	M	M	M	R	U	L	L	H	H	L	L	U	L	U	L	L	M	M	U	L	M	U	L	H	H	M	L
	225	225	400	225	400	225	400	225	400	400	225	400	400	400	225	400	225	225	400	225	225	225	400	400	100	400	225	225	225	400
	16	15	17	14	18	14	18	12	17	16	15	17	18	16	15	17	16	16	18	15	14	13	17	17	10	18	13	14	13	18
	95	90	85	90	85	90	95	80	90	85	80	85	90	90	95	95	95	90	95	80	95	95	95	75	90	95	95	95	95	95
	6	5	3.5	3	3.5	3	8	4	4.5	6	4	4	5	3.5	4	5	6	4	6	8	7	7	8	4.5	4	5	5	6	5	8
	20	20	20	20	15	40	40	50	10	90	70	30	80	25	20	65	50	30	85	80	20	20	35	80	65	35	50	85	60	35
	2	1.8	1.6	1.7	2	1.5	2	1.4	1.7	1.8	2	1.8	1.6	1.4	1.6	1.8	1.5	2	2	2	2	2	2	1.5	1.3	1.8	2	1.6	1.8	2
	90	85	70	55	80	60	30	35	60	40	35	80	60	50	65	35	40	80	40	25	25	30	40	60	20	70	50	40	40	10
	1.5	0.3	0.3	0.3	0.5	0.4	0.8	0.3	0.5	0.3	0.4	0.3	0.3	0.3	0.5	0.3	0.4	0.3	0.8	0.5	0.8	0.6	0.8	0.3	0.2	0.6	0.4	0.5	0.4	0.8
	90	20	40	25	35	30	60	30	40	35	15	40	20	20	20	30	30	25	15	20	30	15	25	30	15	20	30	30	65	20
	38	40	49	37	64	45	52	56	52	42	41	62	49	57	54	55	51	56	47	27	31	37	45	40	33	67	52	52	39	48

Vegetation units	B-3																													
Serial No.	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147
Releve No.	202	205	210	215	251	321	155	170	208	254	327	328	393	394	399	281	383	80	113	157	187	203	212	391	21	112	262	387	398
Station no.	32	32	34	21	31	14	39	42	23	29	14	14	15	15	15	2	22	4	13	39	27	32	34	16	7	13	37	16	15
Altitude (m)	300	440	280	360	310	100	365	420	160	410	60	30	20	40	50	255	180	20	30	310	200	420	180	245	480	35	510	230	40
Slope aspect	SE80	SW44	NW38	SE22	W	SE26	SE20	NW64	NE36	SW16	SW44	NW26	NE54	SW56	SW25	–	NW80	NE54	SW54	NE68	N	NE50	NW54	SE10	SE20	SW46	NW10	SW40	NE58
Slope degree (°)	27	27	28	34	17	31	16	15	23	27	15	12	5	23	22	–	25	22	7	19	10	16	19	35	15	13	10	26	17
Topography	M	U	M	U	M	H	M	U	L	U	H	H	H	H	H	F	M	H	H	L	H	U	H	L	U	M	L	L	H
Quadrat size (m^2)	400	400	400	225	400	100	225	225	100	400	100	100	400	400	400	225	100	400	225	225	225	225	400	225	225	100	400	400	400
T1 - Height (m)	18	16	18	15	18	9	14	12	10	20	9	10	20	20	22	14	10	20	15	14	16	14	17	12	14	10	17	17	23
Coverage (%)	85	85	90	85	85	95	95	60	75	95	90	95	95	95	80	90	80	85	95	95	70	80	75	95	85	80	90	90	95
T2 - Height (m)	4.5	6	4	3	3.5	4.5	6	4	3.5	6	5	6	6	4	4	5	4	8	5	8	8	5	4	5	5	4	7	8	5
Coverage (%)	90	40	5	60	25	35	15	50	15	80	15	40	95	20	20	40	20	70	5	50	50	80	5	60	5	40	50	75	80
S - Height (m)	1.3	1.3	1.5	1.2	1.5	1.8	1.5	1.2	1.6	2	1.8	1.8	2	2.5	2	2.2	1.5	2.3	1.8	2	2	1.5	2	2	1.2	1.3	2.5	1.8	2
Coverage (%)	25	25	90	40	80	70	65	40	70	35	70	50	30	80	90	50	30	40	80	5	50	40	90	3.5	70	25	80	40	85
H - Height(m)	0.3	0.4	0.3	0.3	0.3	0.3	0.8	0.3	0.4	0.2	0.5	0.4	0.4	0.5	0.7	0.7	0.7	0.8	0.3	0.3	0.5	0.3	0.6	0.3	0.4	0.4	0.4	0.5	0.8
Coverage (%)	10	20	25	15	40	40	40	60	40	5	35	25	60	75	90	65	70	30	15	15	70	15	70	20	75	15	10	25	70
Number of species	41	33	40	39	41	29	40	35	31	38	45	38	46	54	33	59	28	49	35	26	65	27	37	36	43	27	32	40	40

B-3						B-4																							
148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176
346	115	204	255	351	401	183	151	169	184	179	146	149	168	178	180	182	196	171	198	197	145	167	189	138	139	195	248	194
6	13	32	29	6	15	27	38	42	27	27	38	38	42	27	27	27	43	42	43	43	38	38	27	26	26	40	37	40
265	50	380	420	280	30	50	10	270	200	50	20	20	280	25	55	30	220	200	180	190	30	50	10	20	15	420	280	440
S	SW77	NW70	SW66	S	NW30	SE30	SW56	SW60	S	NW45	NE86	NW10	NE38	NE70	S	N	NE68	SE82	W	SE40	NE54	NE42	S	SW24	SW68	NE30	NW45	SE54
27	10	29	27	36	13	15	9	26	25	23	24	13	10	10	10	5	12	10	26	30	21	13	25	15	20	16	21	18
L	H	M	M	M	H	H	H	L	H	H	H	H	L	H	H	H	L	L	M	L	H	H	H	H	H	M	L	M
400	100	400	225	225	400	400	100	100	225	400	225	100	100	400	400	400	400	100	400	400	225	100	225	100	400	400	400	400
16	10	18	16	13	21	21	11	9	15	20	14	12	9	18	20	20	18	9	17	23	15	10	14	8	20	16	17	18
90	90	90	85	85	85	90	95	70	90	90	95	85	75	85	90	90	75	70	85	80	90	90	80	85	95	85	80	90
7	5	6	4	5	4	6	6	6	5	6	6	7	5	5	6	8	5	4	5	6	3	4	6	4	8	7	15	6
75	10	50	10	70	70	40	10	70	50	80	10	40	85	50	85	40	70	80	60	75	15	15	10	15	35	90	90	25
1.6	1.2	1.7	1.5	1.4	2	2	2	1.4	1.5	0.2	2	2	1.3	2	2	2	1.5	1.2	1.6	1.2	2	1.5	2	2	2	1.5	1.3	1.5
70	25	85	90	50	90	50	90	30	70	80	90	90	20	40	70	60	80	40	80	70	60	80	30	40	70	10	30	75
0.4	0.3	0.3	0.3	0.4	0.4	1	0.8	0.4	0.5	0.5	0.7	0.8	0.5	0.5	0.3	1	0.3	0.4	0.3	0.3	0.8	0.8	0.2	0.7	1	0.2	0.3	0.3
35	25	10	25	20	90	80	90	50	80	70	85	80	60	60	30	80	20	60	10	70	90	70	60	70	97	10	40	30
28	27	35	36	19	32	60	29	34	40	36	29	24	47	40	40	71	45	40	47	82	49	34	43	28	41	59	58	64

Table 4. Site characteristics for each relevé within Saso-Pinetum densiflorae and *Castanopsis cuspidata* var. *sieboldii*-*Pinus densiflora* community

Vegetation units	C									D					
Serial No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Relevé No.	297	298	299	300	304	306	301	302	303	172	173	174	175	176	177
Station no.	45	45	45	45	45	45	45	45	45	44	44	44	44	44	44
Altitude (m)	1100	1290	1300	1320	1180	1260	1510	1500	1460	80	70	80	100	135	110
Slope aspect	.	W	SW20	SW30	NE54	NE40	SW30	SW14	SW52	S	SE27	NW35	SE37	SE12	S
Slope degree (°)	.	5	3	7	19	14	18	23	20	5	3	6	15	5	5
Topography	F	F	F	F	M	M	U	U	U	H	H	H	H	H	H
Quadrat size (m^2)	400	400	400	400	625	400	100	100	100	225	225	100	100	225	225
T1 - Height (m)	18	17	17	18	22	17	.	.	.	14	15	9	10	14	15
Coverage (%)	90	90	90	90	95	95	.	.	.	90	75	95	85	80	85
T2 - Height (m)	8	9	9	11	6	8	5.5	6	6	6	5	4	4	5	6
Coverage (%)	70	70	80	70	45	25	90	95	95	15	90	70	60	85	15
S - Height (m)	1.8	2	2	3	2	2	2.5	2.2	2.5	1.5	1.5	2	1.5	1.5	1.7
Coverage (%)	10	10	10	15	40	15	15	5	10	60	15	30	30	25	80
H - Height (m)	0.6	0.9	0.7	1	1	1	0.7	1	0.9	0.3	0.3	0.3	0.3	0.4	0.3
Coverage (%)	90	95	95	95	95	95	95	100	95	15	10	30	10	5	15
No. of species	42	33	32	26	40	23	23	10	12	19	17	24	33	23	35

straightforward to determine with the phytosociological method. In addition, the species composition and physiognomy of the communities are complex, due to the interacting influences of successional stages, lumbering, forest fires and afforestation(Toyohara, 1973; 1984). Nevertheless, Suzuki(1966) classified the pine forests of Japan into four associations based on ericaceous plants found in the shrub layer, classing the Pinus densiflora forests as Pinion densiflorae Suzuki 1966.

In Korea, the pine forests have also been classified using the ericaceous plants(Kim and Yim, 1986; Yim and Kim, 1992). However, in the Korean pine forests these species, especially *Rhododendron mucronulatum* and *R. schlippenbachii*, have extensive distributions, with no clear preferences for specific types of site. Therefore, we conclude that using Rhododendron species as character species for classifying the vegetation would present major difficulties. Instead, the pine forests should be classified using species whose distributions in Korea are correlated with latitude and elevation(Song, 1992), as in the study presented here.

(1) Rhododendro–Quercetalia mongolicae Kim 1990

Lindero-Quercion mongolicae Kim 1990 em. Kim 1992

Character and differential species: *Lindera obtusiloba, Rhus trichocarpa, Lespedeza maximowiczii, Fraxinus sieboldii, F. rhynchophylla, Rhododendron schlippenbachii, Lespedeza bicolor, Styrax obassia, Acer pseudo-sieboldianum, Carpinus laxiflora, Weigela subsessilis, Ligustrum obtusifolium, Carex ciliato-marginata.*

The order Rhododendro-Quercetalia mongolicae was divided into Pino koraiensis-Quercion mongolicae and Lindero-Quercion mongolicae. The former occurred in the northern parts of the Korean Peninsula, while the latter occupied stands on the slopes and ridges of the montane zone(below 1,400m) in the middle parts of the Korean Peninsula(Kim, 1990). The observations suggest that most stands should be included in this alliance except *Castanopsis cuspidata* var. *sieboldii-Pinus densiflora* community stands in the warm-temperate zone.

(2) Camellietalia japonicae Oda et Sumata 1966

Character species: *Camellia japonica, Eurya japonica, Castanopsis cuspidata* var. *sieboldii* and *Neolitsea sericea.*

This order contains two alliances: Ardisio-Castanopsion and Pittosporion tobira

1) Ardisio-Castanopsion Miyawaki *et al.* 1971

Character species: *Cymbidium goeringii, Ophiopogon japonica, Ardisia japonica, Stauntonia hexaphylla, Kadsura japonica* and *Quercus salicina.*

Castanopsis cuspidata var. *sieboldii-Pinus densiflora* community, investigated in Bogildo Island, Wando province is included to the alliance Ardisio-Castanopsion. Bogildo Island is covered by an evergreen broad-leaved forest and its warmth and coldness indices are 111.9℃·month and -3.6℃·month, respectively.

3. Characteristics of the association and communites

A. *Quercus mongolica–Pinus densiflora* community

Differential species: *Quercus mongolica, Chrysanthemum zawadskii* and *Viola orientalis.*

This community was mainly distributed in geographically similar, although much higher, areas to *Quercus serrata-Pinus densiflora* community. In other words, it tends to occur at high altitudes in the southern parts and at low altitudes in the central, sub-montane parts of the cool temperate zone. Lee and Lee(1989), who surveyed the pine forests in Korea, reported that *Q. mongolica* tends to be the most abundant of the dominant *Quercus* spp. group at higher latitudes.

In summary, this community was dominated by *Pinus densiflora* in the tree layer and *Quercus mongolica* in the subtree layer. It mainly occupies the steep slopes, drier sites on the upper slopes and ridges of the montane zone in central-northern parts of the Korean Peninsula. The succession of this unit is expected to give rise to *Q. mongolica* forests in the future except in edaphic climax regions(Choung and Yang, 1998; Kil *et al.*, 1996; Choung and Hong, 2006).

Quercus mongolica-Pinus densiflora community was divided into three subcommunities: Typical subcommunity, *Vaccinium koreanum* subcommunity and *Rhododendron micranthum* subcommunity.

A-1. Typical subcommunity

This subcommunity was distributed more extensively in the mountainous regions of the study area, compared to the *Vaccinium koreanum* subcommunity and *Rhododendron micranthum* subcommunity, which had more patchy and localized distributions. This unit was recognized mainly between 300m and 800m a.s.l., although the altitudinal range covered differed at various latitudes on Mts. Seorak, Maebong, Odae, Juklim, Deokgo, Chiak, Gamakbong, Baegun, Bukhan, Yongdu, Chilgab, Gyeryong, Juwang, Palgong and Jiri(Figure 1).

The slope was 27.5° and the average number of species per relevé was 29.9(range 9~54)(Table 1, 2). The subcommunity mostly showed three to four layers, but sites with two layers were observed in some regions adjacent to rocky sites. The average tree height was 14 m, and the coverage of the tree, subtree, shrub and herb layers was 85.8%, 37.3%, 43% and 42.7%, respectively. The major dominant species, in order of r-NCD(Table 5) are as follows: *Pinus densiflora*(100.0), *Quercus mongolica*(23.1), *Carex humilis*(8.7), *Rhododendron mucronulatum*(8.6), *Spodiopogon sibiricus*(7.9), *R. schlippenbachii*(3.4), *Artemisia keiskeana*(3.2), *Rhus trichocarpa*(1.8), *Q. variabilis*(1.8), *Fraxinus sieboldii* (1.6), *Polygonatum odoratum* var. *pluriflorum*(1.5) and *Styrax obassia*(1.2).

A-2. *Vaccinium koreanum* subcommunity

Differential species: *Vaccinium koreanum*.

This subcommunity was found on upper slopes ranging from 420m to 820m a.s.l. in the Uljin area and ridges of Mts. Seorak, Odae, Songli and Palgong(Figure 1). *Vaccinium koreanum* has been previously described as a main species of *Vaccinium koreanum* subcommunity, a drier type of *Quercus mongolica* community, which repeatedly occurs in a discontinuous belt on prominent topographical features with *Q. mongolica* (Kim, 1990; Lee *et al.*, 1994; Song, 1988). In the present study, this subcommunity was found to be restricted to the ridges and mother rocks of exposed stands.

The average slope and number of species per relevé were 30.0° and 29.2(range 12~46), respectively. The subcommunity was composed of four layers. The average tree height was 15.2m, and cover values were 87.2% in the tree layer, 44.4% in the subtree layer, 67.2% in the shrub layer, and 52.2% in the herb layer (Table 1, 2). The major dominant species in order of relative NCD were: *Pinus densiflora*(100.0), *Quercus mongolica* (27.1), *Rhododendron schlippenbachii*(23.9), *R. mucronulatum*(21.8), *Vaccinium koreanum*(7.9), *Fraxinus sieboldiana*(6.8), *Carex humilis*(4.6), *Chrysanthemum zawadskii*(3.9), *Rhus trichocarpa* (3.9), *Artemisia keiskeana*(2.3) and *Spodiopogon sibiricus*(2.2)(Table 5). Kang and Lee(1991) classified the *Pinus densiflora* association as belonging to the subassociation, describing it as having three strata and simple floristic composition in the Mt. Songli area.

A-3. *Rhododendron micranthum* subcommunity

Differential species: *Rhododendron micranthum*.

Rhododendron micranthum subcommunity was found to the Uljin region among the areas studied(Figure 1). This subcommunity, which includes *Quercus mongolica*, occurred mainly in stands on mid and upper slopes and mountain ridges of the range at about 300m a.s.l. However, it also occurred in some localities adjacent to block fields, although it was associated with *Q. variabilis* in rocky sites. The forest showed relatively high coverage, especially in open stands. *Rhododendron micranthum,* a shrubby, evergreen, broad-leaf plant is found in sunny sites at the feet of mountains in Gyeongbuk, Chungbuk and Gangwon provinces in the central part of the Korean Peninsula(Lee, 1996). Yun and Hong(2000) reported that the *Rhododendron micranthum* community(differential species: *Rhododendron micranthum*) occurs in *Pinus densiflora* var. *erecta* forests of the Uljin area.

The average slope and number of species per relevé were 35.7° and 25.4(range 16~48), respectively. The subcommunity had four layers, the average tree height was 13.3 m and the coverage was 85.5% in the tree layer, 47.5% in the subtree layer, 46% in the shrub layer and 33% in the herb layer(Table 1, 2). The dominant species in order of relative NCD were *Pinus densiflora*(100.0), *Quercus mongolica*(27.7), *Rhododendron micranthum* (15.1), *Spodiopogon sibiricus*(8.7), *Q. variabilis*(8.5), *Fraxinus sieboldiana*(7.9), *Carex humilis*(4.9), *Artemisia keiskeana*(2.2), *Chrysanthemum zawadskii* var. *latilobum*(1.6) and *Aster scaber*(1.1). The

Table 5. Relative net contribution degree(r-NCD) values on each community of *Pinus densiflora* forests in Korea

A: *Quercus mongolica-Pinus densiflora* community
A-1: Typical subcommunity
A-2: *Vaccinium koreanum* subcommunity
A-3: *Rhododendron micranthum* subcommunity
B: *Quercus serrata-Pinus densiflora* community
B-1: Typical subcommunity
B-2: *Juniperus rigida* subcommunity
B-3: *Styrax japonica* subcommunity
B-4: *Eurya japonica* subcommunity
C: Saso-Pinetum densiflorae Yim *et al*. 1990
D: *Castanopsis cuspidata* var. *sieboldii* -*Pinus densiflora* community

Vegetation units:	A			B				C	D	Total
	A-1	A-2	A-3	B-1	B-2	B-3	B-4			
Number of relevé:	42	9	10	61	35	57	23	9	6	252
Character and differential species of association and communities										
Quercus mongolica	23.1	27.1	27.7	6.3	0.7	0.4	m	·	·	4.73
Chrysanthemum zawadskii	0.8	3.9	·	0.1	m	·	·	·	·	0.09
Viola orientalis	0.3	0.1	0.4	0.1	m	m	·	·	·	0.05
Vaccinium koreanum	·	7.9	·	·	·	·	·	·	·	0.01
Rhododendron micranthum	·	·	15.1	m	·	·	·	·	·	0.03
Quercus serrata	0.4	0.1	0.8	12.4	9.8	12.7	6.4	·	0.4	6.79
Carex lanceolata	m	m	0.1	1.5	2.8	2.1	2.6	·	·	1.15
Zanthoxylum schinifolium	0.1	·	0.1	0.2	0.2	0.4	0.2	m	·	0.20
Smilax nipponica	0.2	·	·	1.0	m	0.2	m	·	·	0.23
Calamagrostis arundinacea	0.2	m	0.1	0.5	0.3	1.1	m	·	·	0.35
Viburnum erosum	m	·	·	m	0.1	2.0	0.7	·	0.5	0.30
Oplismenus undulatifolius	m	·	m	0.4	0.4	1.0	0.5	·	·	0.30
Corylus heterophylla var. *thunbergii*	m	m	·	0.1	0.2	0.3	0.2	·	·	0.11
Paederia scandens	m	·	·	m	0.1	0.2	0.2	·	0.8	0.07
Lindera glauca	·	·	·	m	0.2	0.2	0.5	·	·	0.07
Isodon inflexus	m	·	m	m	m	0.3	m	·	·	0.04
Celastrus orbiculatus	m	m	·	m	m	0.1	m	·	·	0.03
Quercus aliena	·	·	m	0.1	2.2	0.1	1.4	·	·	0.21
Rhus chinensis	m	·	m	0.2	m	0.2	m	·	·	0.08
Platycarya strobilacea	·	·	·	m	m	0.3	0.8	·	·	0.06
Quercus dentata	m	m	·	0.2	0.2	0.2	m	·	·	0.10
Juniperus rigida	m	·	m	m	2.8	0.2	0.2	·	m	0.21
Rhododendron yedoense var. *poukhanense*	·	·	m	m	3.3	m	0.6	m	·	0.15
Styrax japonica	m	·	·	m	0.4	15.3	5.8	·	·	1.83
Quercus variabilis	1.8	m	8.5	0.5	1.0	4.5	0.8	·	·	1.53
Eurya japonica	·	·	·	·	·	·	8.2	·	12.5	0.11
Trachelospermum asiaticum var. *intermedium*	·	·	·	·	m	m	7.7	·	4.4	0.11
Ilex crenata	·	·	·	·	m	m	m	1.9	·	0.01
Sasa quelpaertensis	·	·	·	·	·	·	·	100.0	·	0.13
Quercus mongolica var. *grosseserrata*	·	·	·	·	·	·	·	7.4	·	0.01
Asarum maculatum	·	·	·	m	·	·	·	1.5	·	m
Prunus maximowiczii	·	·	·	m	·	·	·	1.2	·	m
Schizophragma hydrangeoides	·	·	·	·	·	·	·	0.9	·	m
Mitchella undulata	·	·	·	·	·	m	·	0.6	·	m
Daphniphyllum macropodum	·	·	·	·	·	·	·	4.7	·	0.01
Quercus myrsinaefolia	·	·	·	·	·	·	·	·	3.6	m
Castanopsis cuspidata var. *sieboldii*	·	·	·	·	·	·	·	·	19.2	0.01
Raphiolepis umbellata	·	·	·	·	·	·	·	·	0.5	m
Character and differential species of Lindero-Quercion mongolicae and Rhododendro-Quercetalia mongolicae										
Lindera obtusiloba	1.2	1.7	1.0	1.8	0.3	1.6	1.0	m	m	1.12
Rhus trichocarpa	1.8	3.9	0.3	3.3	1.5	1.6	1.0	·	0.1	1.79
Lespedeza maximowiczii	0.7	0.1	m	2.3	0.2	1.1	1.1	·	·	0.87
Fraxinus sieboldiana	1.6	6.8	7.9	0.9	2.3	1.8	3.1	·	m	1.83
Fraxinus rhynchophylla	0.9	0.1	m	1.4	m	0.5	m	·	·	0.44
Rhododendron schlippenbachii	3.4	23.9	0.9	2.9	0.9	1.2	0.1	·	·	1.93
Lespedeza bicolor	0.3	0.3	0.5	0.3	0.7	0.3	0.8	·	·	0.34
Styrax obassia	1.2	0.6	0.5	3.8	m	0.1	m	1.7	·	0.87
Acer pseudo-sieboldianum	0.7	0.5	m	2.1	m	0.1	1.0	4.3	·	0.67
Carpinus laxiflora	0.1	·	·	1.2	m	0.5	0.9	14.9	·	0.57
Weigela subsessilis	0.1	0.1	m	0.2	m	0.1	0.1	0.1	·	0.09
Ligustrum obtusifolium	·	·	·	m	0.1	0.1	0.2	0.2	·	0.03
Carex ciliato-marginata	m	0.1	m	m	0.1	0.3	1.7	0.1	·	0.13
Character and differential species of Ardisio-Castanopsietum sieboldii										
Cymbidium goeringii	·	·	·	m	0.2	0.2	0.6	·	1.2	0.07
Ophiopogon japonicus	·	·	·	·	m	m	m	m	0.8	m
Ardisia japonica	·	·	·	·	·	·	·	·	1.1	m
Kadsura japonica	m	·	·	·	·	·	m	·	m	m
Stauntonia hexaphylla	·	·	·	·	·	·	m	·	0.1	m
Quercus salicina	·	·	·	·	·	·	·	·	1.5	m
Character species of Camellietalia japonicae and Camellietea japonicae										
Ligustrum japonicum	·	·	·	·	m	·	0.2	·	0.8	m
Camellia japonica	·	·	·	·	·	·	m	·	20.0	0.02
Neolitsea sericea	·	·	·	·	·	·	m	·	0.8	m
Quercus acuta	·	·	·	·	·	·	·	·	0.7	m

Table 5. (Continued)

Companions										
Pinus densiflora	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.00
Rhododendron mucronulatum	8.6	21.8	6.6	6.7	19.4	4.0	3.9	0.1	0.1	7.17
Spodiopogon sibiricus	7.9	2.2	8.7	5.4	3.7	1.7	0.5	·	·	3.39
Artemisia keiskeana	3.2	2.3	2.2	3.8	3.1	1.1	0.8	·	·	2.17
Smilax china	m	m	m	0.4	1.9	1.5	4.0	1.1	1.1	0.89
Atractylodes japonica	0.5	0.5	2.3	0.4	0.9	0.5	0.2	·	·	0.51
Carex humilis	8.7	4.6	4.9	4.6	4.0	1.0	2.2	·	m	3.42
Aster scaber	0.4	0.5	1.1	0.3	0.4	0.8	0.8	·	0.1	0.48
Prunus sarsentii	0.4	0.2	·	1.9	0.5	1.9	1.1	m	·	0.96
Pteridium aquilinum var. *latiusculum*	0.2	m	m	0.5	0.9	0.6	1.4	0.1	0.3	0.51
Pyrola japonica	0.4	0.3	m	0.4	0.7	0.3	0.9	·	0.5	0.39
Polygonatum odoratum var. *pluriflorum*	1.5	1.1	m	0.9	0.1	0.2	0.1	·	0.1	0.46
Symplocos chinensis for. *pilosa*	0.2	0.1	m	0.3	m	0.4	0.3	·	0.3	0.21
Disporum smilacinum	0.4	0.5	·	2.1	0.4	3.5	6.4	0.5	0.8	1.73
Stephanandra incisa	0.1	·	m	0.7	0.2	1.2	5.6	·	·	0.68
Sorbus alnifolia	0.1	m	m	0.2	0.1	0.7	0.4	0.1	0.1	0.22
Parthenocissus tricuspidata	0.1	·	·	0.5	0.1	0.6	m	0.2	·	0.24
Patrinia villosa	0.1	0.1	0.9	0.3	0.2	0.1	m	·	·	0.15
Smilax sieboldii	m	0.1	·	0.2	0.1	0.2	0.1	0.1	·	0.12
Castanea crenata	m	m	m	0.3	0.5	0.3	m	·	m	0.17
Peucedanum terebinthaceum	0.4	0.5	0.4	0.2	m	m	m	·	·	0.11
Cocculus trilobus	m	m	m	m	0.2	0.3	0.2	·	·	0.08
Potentilla freyniana	0.1	m	0.8	0.1	0.3	m	m	·	·	0.11
Lindera erythrocarpa	m	·	·	m	m	0.7	0.4	4.4	m	0.19
Solidago virga-aurea var. *asiatica*	m	·	0.6	0.1	m	0.1	0.1	·	·	0.07
Carex siderosticta	0.1	·	·	0.8	0.3	m	1.1	·	·	0.26
Callicarpa japonica	m	·	m	0.2	m	0.1	0.6	·	·	0.09
Melica onoei	0.2	0.3	·	m	0.3	0.3	0.4	·	m	0.16
Lespedeza cyrtobotrya	0.3	0.3	0.2	0.1	0.2	m	m	·	·	0.09
Melampyrum roseum	0.5	0.1	·	0.2	m	m	m	·	·	0.09
Rubus crataegifolius	0.1	0.1	·	0.1	m	m	m	·	·	0.04
Vaccinium oldhami	·	·	·	m	0.8	0.3	0.4	0.1	0.1	0.14
Dioscorea japonica	m	·	·	m	m	0.1	m	·	m	0.03
Syneilesis palmata	m	·	m	0.1	m	m	0.1	·	·	0.03
Kalopanax pictus	m	·	·	0.1	m	m	m	0.6	·	0.03
Rosa multiflora	m	·	m	m	0.1	0.1	0.1	m	·	0.03
Viola rossii	0.1	0.1	m	m	m	0.1	0.2	m	·	0.05
Chrysanthemum zawadskii var. *latilobum*	0.1	0.1	1.6	0.1	0.1	m	m	·	·	0.07
Platycodon grandiflorum	m	·	0.2	m	0.1	m	·	·	·	0.02
Hosta longipes	m	m	·	0.1	m	m	0.1	·	·	0.03
Indigofera kirilowi	m	m	·	m	0.4	0.2	0.1	·	0.1	0.07
Vitis amurensis	m	·	·	0.1	m	m	m	·	·	0.02
Viola dissecta var. *chaerophylloides*	m	m	·	m	m	0.1	0.2	·	·	0.04
Miscanthus sinensis var. *purpurascens*	m	m	·	m	0.6	0.1	1.2	·	·	0.12
Maackia amurensis	m	0.1	·	m	m	0.2	m	0.1	·	0.04
Ampelopsis brevipedunculata var. *heterophylla*	m	m	·	m	m	0.1	m	m	·	0.02
Pueraria thunbergiana	m	·	m	m	m	0.1	m	·	m	0.02
Hemerocallis fulva	m	·	·	0.1	m	m	m	·	·	0.02
Robinia pseudo-acacia	m	·	m	m	0.3	m	·	·	·	0.03
Lonicera japonica	·	·	m	m	m	m	0.1	·	m	0.01
Lysimachia clethroides	m	m	m	m	m	m	m	·	·	0.02
Lonicera praeflorens	m	·	·	m	·	m	m	·	0.1	0.01
Potentilla fragarioides var. *major*	m	·	m	m	m	m	0.1	·	·	0.02
Clematis mandshurica	m	·	m	m	m	m	m	·	·	0.01
Astilbe chinensis var. *davidii*	m	0.1	m	m	m	m	m	·	·	0.01

* m: Minute r-NCD values

occurrence of *Rhododendron micranthum* in the shrub and herb layers was particularly noteworthy. Also, the relative NCD ranking of *Q. variabilis* was higher in the subtree layer here than in other subcommunity, because the habitats of this assemblage were dry block fields adjacent to the sites(Table 5) .

B. *Quercus serrata–Pinus densiflora* community

Differential species: *Quercus serrata, Carex lanceolata, Zanthoxyrum schinifolium, Smilax nipponica, Calamagrostis epigeios, Viburnum erosum, Oplismenus undulatifolius, Corylus heterophylla* var. *thunbergii, Paederia scandens, Lindera glauca, Isodon*

inflexus, Celastrus orbiculatus, Q. aliena, Rhus chinensis, Platycarya strobilacea and *Q. dentata.*

This community was distributed widely in the center of sub-montane and hilly areas from the central to the southern parts of the Korean Peninsula. *Quercus serrata-Pinus densiflora* community has been heavily influenced by human activities, because its habitats are close to urban areas. Consequently, it is less 'natural' than the *Quercus mongolica-Pinus densiflora* community. Lee and Lee(1989) reported that *Quercus serrata* was a major dominant species in the south and south-coast provinces, and the *Pinus densiflora-Quercus serrata* subassociation was characterized with *Quercus serrata.*

In Japan, Yoshioka(1958) identified a *Pinus densiflora-Quercus serrata* association(consisting of *Quercus serrata, Castanea crenata, Q. mongolica* var. *grosseserrata, Rhus trichocarpa* and *Vaccinium oldhamii*) in the cool temperate region in an ecological study of pine forests in Japan. Later, when Toyohara (1973) re-investigated the Japanese pine forests, the *Pinus densiflora-Quercus serrata* association was merged with other associations belonging to the alliance Querco-Pinion densiflorae. In Korea, however, since the distribution of *Q. serrata* is strongly correlated with that of *Pinus densiflora* in the middle of the sub-montane zone and hills, we recognize this as a distinct community.

On the other hand, the *Quercus serrata-Pinus densiflora* community appears to have been formed by invasion of *Pinus densiflora* stands by *Q. serrata.* It has also been proposed that the community represents a stage of succession from the *Pinus densiflora* forest to *Q. serrata* forest since it has considerable amounts of *Q. serrata* in the subtree and shrub layers(Kim, 1988; Kim, 1989; Yim, 1990; Choung and Hong, 2006). *Quercus serrata-Pinus densiflora* community was divided into four subcommunities: Typical subcommunity, *Juniperus rigida* subcommunity, *Styrax japonica* subcommunity and *Eurya japonica* subcommunity.

B-1. Typical subcommunity

The habitats of this subcommunity were located in the montane parts of cool temperate central/northern regions. The subcommunity was chiefly observed in the montane region between 200m and 500m a.s.l., but was also seen, to a lesser extent, below 100m. The localities in which it occurred were Mts. Noin, Goseong, Seorak, Odae, Bukhan, Chiak, Gamakbong, Baegun, Bukhan, Yongmun, Gyeryong, Songli, Geumo, Gaya, Deokyu and Mudeung and the regions of Sokcho, Yangyang, Uljin, Weolseong, Miryang and Namweon(Figure 1). Many stands of this subcommunity included species in common with *Quercus mongolica-Pinus densiflora* community, owing to their occurrence in similar habitats.

The average slope and number of species per relevé were 22° and 39.2(range 8~67), respectively. The subcommunity had three to four layers, the average tree height of the upper crown was 16.6m, and cover values were 87.9% in the tree layer, 55.3% in the subtree layer, 48.9% in the shrub layer and 39% in the herb layer(Table 1, 3). Species contribution rankings by r-NCD(Table 5) in this subcommunity were as follows, *Pinus densiflora* (100.0), *Quercus serrata*(12.4), *Rhododendron mucronulatum*(6.7), *Q. mongolica*(6.3), *Spodiopogon sibiricus*(5.4), *Carex humilis*(4.6), *Artemisia keiskeana* (3.8), *Styrax obassia*(3.8), *Rhus trichocarpa*(3.3), *R. schlippenbachii*(2.9), *Lespedeza maximowiczii*(2.3) and *Disporum smilacinum*(2.1).

B-2. *Juniperus rigida* subcommunity

Differential species: *Juniperus rigida* and *Rhododendron yedoense* var. *poukhanense.*

This subcommunity, found in some parts of the mountainous regions of Mts. Seorak, Bukhan, Chilgab, Songli, Juwang, Geumo, Palgong, Gaya, Soyo, Kyeongsu and Mudeung, occurred in dry habitats among the lower montane and hilly areas in Sokcho, Uljin, Gyeongju, Weolseong, Gori, Namweon, Yeonggwang and Suncheon(Figure 1).

Kim and Kim(1988) reported that the *Juniperus rigida-Pinus densiflora* community appears as an edaphic climax at dry habitats of mountain ridges. The subcommunity has developed on exposed parent rock around Seoul and central parts of the Korean Peninsula. In these stands *Juniperus rigida* coexists with *Pinus densiflora.* The character species are *P. densiflora, J. rigida, Festuca ovina, Miscanthus sinensis* var. *purpurascens, Atractylodes japonica, Lespedeza cyrtobotrya* and *Zanthoxylum schinifolium* for both the

Pinus densiflora community and the *Juniperus rigida-Pinus densiflora* community(Kim *et al.*, 1995; Lee *et al.*, 1995). Meanwhile, in Japan, Toyohara(1984) reported that the subassociation Juniperetosum rigidae, belonging to Cladio aggregatae-Pinetum densiflorae, occurred on dry sites in coastal areas at altitudes between 40m and 200m.

The average slope and number of species per relevé were 25.7° and 32.9(range 11~65), respectively. The subcommunity had three to four layers, the average tree height of the upper crown was 13.4m, and cover values were 86.7% in the tree layer, 30.6% in the subtree layer, 57.7% in the shrub layer and 43% in the herb layer, respectively(Table 1, 3). The major dominant species in order of r-NCD for this subcommunity were as follows: *Pinus densiflora*(100.0), *Rhododendron mucronulatum* (19.4), *Quercus serrata*(9.8), *Carex humilis*(4.0), *Spodiopogon sibiricus*(3.7), *R. yedoense* var. *poukhanense*(3.3), *Artemisia keiskeana*(3.1), *C. lanceolata*(2.8), *Juniperus rigida*(2.8), *Fraxinus sieboldiana*(2.3), *Q. aliena*(2.2) and *Smilax china*(1.9) (Table 5). Since *Quercus* spp. such as *Q. mongolica, Q. serrata, Q. aliena* and *Q. dentata* occurred in the subtree and shrub layers of various stands, this subassociation is expected to form mixed forests of the pine and *Quercus* spp. in the future.

B-3. *Styrax japonica* subcommunity

Differential species: *Styrax japonica* and *Quercus variabilis*.

This subcommunity was found in the regions(Figure 1) of Mt. Seorak, Sokcho, Mt. Odae, Mt. Deokgo, Ganghwado Island, Baekryeongdo(I.), Daecheongdo (I.), Anmyeondo(I.), Mt. Chilgab, Mt. Gyeryong, Mt. Geumo, Mt. Palgong, Kyeongju, Miryang, Geojedo(I.), Geochang, Sancheong, Hamyang, Hadong, Mt. Deokyu, Buan, Mt. Kyeongsu, Mt. Soyo, Mt. Jiri, Mt. Bangjang, Mt. Suryeon, Hwasun and Suncheon on low slopes, hilly parts of the mountainous regions, and a moist streamside, which was exposed to human impact, because a dwelling was found below 500m a.s.l. in the same region. Kim and Jegal(1999) reported that stands of Styrax japonica developed vigorously by the streams and on lowland slopes affected by anthropogenic agents such as air and soil pollutants.

The average slope and number of species per relevé were 19.4° and 41.1(range 27~67), respectively. Structurally, there were four layers. The average tree height of the upper crown was 15.6m, and coverage was 88.6% in the tree layer, 43.3% in the subtree layer, 51.8% in the shrub layer, and 34.1% in the herb layer(Table 1, 3). The dominance ranking of the species by r-NCD (Table 5) was as follows: *Pinus densiflora*(100.0), *Styrax japonica*(15.3), *Quercus serrata*(12.7), *Q. variabilis*(4.5), *R. mucronulatum*(4.0), *Disporum smilacinum*(3.5), *Carex lanceolata*(2.1), *Viburnum erosum*(2.0), *Prunus sargentii*(1.9), *Fraxinus sieboldiana*(1.8) and *Spodiopogon sibiricus*(1.7). Notably, *Styrax japonica* is the most dominant species in the subtree layer, presumably because lumbering has opened the crown and increased light availability in this layer. Also, *Carpinus coreana* was conspicuous in the subtree and shrub layers of these stands. The stands of Anmyeondo(I.), Baekryeongdo(I.) and Daecheongdo (I.), which are located on the Island of Seohae(the Yellow Sea), were included in this subcommunity.

B-4. *Eurya japonica* subcommunity

Differential species: *Eurya japonica* and *Trachelospermum asiaticum* var. *intermedium*.

This subcommunity was found, to a minor extent, in coastal regions and the Islands of Namhae in the southern sea(Chang *et al.*, 1988; Lee *et al.*, 1997). The distribution area was the sub-montane zone at around 300m a.s.l. on Gori, Yeonggwang, Mt. Jiri, Mt. Geumjeong, Mt. Mudeung, Mt. Palryeong, Mt. Duryun and Geojedo Island (Figure 1). The warmth index(WI) was greater than 100℃·month, which corresponds to warm-temperate regions(Yim and Kira, 1975).

This subcommunity is similar to *Castanopsis cuspidata* var. *sieboldii-Pinus densiflora* community, including common evergreen broad-leaved species such as *Eurya japonica* and *Trachelospermum asiaticum* var. *intermedium*(and to a lesser extent *Ligustrum japonicum, Camellia japonica, Neolitsea sericea, Ardisia japonica* and *Raphiolepis umbellata*). Characteristically there was a relatively low abundance of evergreen broad-leaved trees and relatively high frequency of *Quercus serrata* at the study sites.

The slope and average number of species for the

relevé were 17.9° and 45.2(range 24~82), respectively. The subcommunity comprised four layers. The average tree height of the upper crown was 15.5m, and the mean coverage was 85.4% in the tree layer, 46.8% in the subtree layer, 59.8% in the shrub layer and 59% in the herb layer(Table 1, 3). The dominant species according to r-NCD(Table 5) was *Pinus densiflora*(100.0), *Eurya japonica*(8.2), *Trachelospermum asiaticum* var. *intermedium*(7.7), *Quercus serrata*(6.4), *Disporum smilacinum*(6.4), *Styrax japonica*(5.8), *Stephanandra incisa*(5.6), *Smilax china*(4.0), *Rhododendron mucronulatum*(3.9), *Fraxinus sieboldiana*(3.1) and *Carex lanceolata*(2.6). The average number of species per relevé was higher in this than in any other subcommunity(with 45.2 plant species in the communities), because there were plants of both warm-temperate and temperate zone in these habitats.

C. Saso-Pinetum densiflorae Yim *et al.* 1990.

Character and differential species: *Ilex crenata, Sasa quelpaertensis, Quercus mongolica* var. *grosseserrata (Quercus* × *grosseserrata, Q. crispula), Asarum maculatum, Prunus maximowiczii, Schizophragma hydrangeoides, Mitchella undulata* and *Daphniphylum macropodum.*

This association was dominated by *Sasa quelpaertensis* in the herb layer, which formed an almost complete carpet(Combined cover-abundance scale, DS 5.5). *Q. mongolica* var. *grosseserrata*, a canopy tree, was found in the subtree and herb layers as + and 2 in the coverage value. This is distinguished from those in the central-southern areas of the Korean Peninsula, with coexistence of *Q. mongolica* and *Q. serrata* in the stand. However the association seems partially homologus in terms of character species with *Quercus mongolica-Pinus densiflora* community and *Quercus serrata-Pinus densiflora* community in the inland regions. Furthermore, the character and differential species of the alliance Lindero-Quercion mongolicae were common (e.g. *Acer pseudo-sieboldianum, Lindera obtusiloba, Styrax japonica* and *Weigela subsessilis* etc. including *Carpinus laxiflora* in the subtree and shrub layers). However, the association also often includes evergreen broad-leaved plants, such as *Ilex crenata* and *Hedera rhombea,* that are character species of *Quercus serrata-Eurya japonica* subcommunity, found in the warm-temperate zone in Korea. The habitats of Saso-Pinetum densiflorae were located at altitudes between 1,100m and 1,500m a.s.l. on Mt. Halla(parts of the Tamna valley and Yeongsil) on Cheju Island(Figure 1). Therefore, the association is very distinctive because it is found in a transitional zone where both temperate and subtropical plants occur. These species are located at high altitudes in cool temperate, northern parts of Korea, and at lower latitudes in warm-temperate parts. This association was described as the *Pinus densiflora-Sasa quelpaertensis* association by Shin(1981). Later, Yim *et al.*(1990) defined Saso-Pinetum densiflorae, citing *P. densiflora* and *S. quelpaertensis* as the character species. The association corresponds to the Querco-Pinion densiflorae H. Suzuki et Toyohara(1971) proposed in Japan.

The average slope and number of species per relevé were 13.6° and 26.8(range 10~42), respectively. The association had three to four layers, the average height of the tree layer was 18.2m, and the average cover values were 91.7% in the tree layer, 71.1% in the subtree layer, 14.4% in the shrub layer, and 95% in the herb layer (Table 1, 4). The ranking of species in order of dominance, according to r-NCD(Table 5), in this association was as follows: *Pinus densiflora*(100.0), *Sasa quelpaertensis*(100.0), *Carpinus laxiflora*(14.9), *Quercus mongolica* var. *grosseserrata*(7.4), *Daphniphyllum macropodum*(4.7), *Lindera erythrocarpa*(4.4), *Acer pseudo-sieboldianum*(4.3), *Ilex crenata*(1.9), *Styrax obassia*(1.7), *Asarum maculatum*(1.5) and *Prunus maximowiczii*(1.2). The herb layer cover value(95%) is very noteworthy, as is the dominance of *Sasa quelpaertensis*, which seems to obstruct the germination and growth of other plants in this layer.

D. *Castanopsis cuspidata* var. *sieboldii-Pinus densiflora* community

Differential species: *Castanopsis cuspidata* var. *sieboldii, Quercus myrsinaefolia* and *Raphiolepis umbellata.*

This community was distributed at sites below 150m a.s.l. in the piedmont area of Bogildo Island in the southern sea off the Korean Peninsula(Figure 1). The

floristic composition of the community differs from that of *Quercus mongolica-Pinus densiflora* community and *Quercus serrata-Pinus densiflora* community by having *Castanopsis cuspidata* var. *sieboldii, Eurya japonica, Camellia japonica* and *Q. myrsinaefolia* in the shrub and herb layers(Kim *et al.*, 1989). The stand characteristically had low frequencies of *Q. mongolica, Q. serrata* and *Q. variabilis*, which were major component species of the above two community. The community was restricted to the warm-temperate zone, where the warmth index(WI) is greater than 110℃·month, on the islands off the south-west coast. Evergreen broad-leaved species such as *E. japonica, C. cuspidata* var. *sieboldii, Trachelospermum asiaticum* var. *intermedium, Hedera rhombea, Camellia japonica, Ardisia japonica, Ligustrum japonicum, Machilus thunbergii, M. japonica* and *A. crenata*, which are the character species of the class Camellietea japonicae Miyawaki et Ohba(1963), were the most abundant species of the evergreen broad-leaved forest zone.

The floristic composition of the community included various species found in the evergreen broad-leaved forest, such as *Quercus glauca, C. cuspidata* var. *sieboldii, Vaccinium bracteatum, Ligustrum japonicum* and *Cinnamomum japonicum*: character species of the alliance Cyclobalanopsio-Pinion densiflorae H. Suzuki et Toyohara(1971). These species occur in the warm-temperate pine forest of Japan. Therefore, it can be regarded as a category of the alliance described above.

The average slope and number of species per relevé were 6.5° and 25.2(range 17~35), respectively. The community had four layers. The average height of the tree layer was 12.8m, and average cover values were 85% in the tree layer, 55.8% in the subtree layer, 40% in the shrub layer, and 14.2% in the herb layer(Table 1, 4). The species of highest rank by r-NCD values(Table 5) were: *Pinus densiflora*(100.0), *Camellia japonica* (20.0), *Castanopsis cuspidata* var. *sieboldii*(19.2), *Eurya japonica*(12.5), *Trachelospermum asiaticum* var. *intermedium*(4.4), *Quercus myrsinaefolia*(3.6), *Q. salicina*(1.5), *Cymbidium goeringii*(1.2), *Ardisia japonica*(1.1) and *Smilax china*(1.1). A notable feature was the low coverage of the ground layer(<15%) of this community. In addition, average number of species per relevé was lower(25 species) for this community than for any of the others.

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