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ORIGINAL ARTICLE

Studies of Vegetation Structure Analysis and Vegetation Transition over 25 years of Evergreen Broad-leaved Forest in Hong-Do Island

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Abstract

This study aims at classifying and interpreting on the vegetation structure and the vegetation transition over 25 years (between 1986 and 2010), and the correlation with the change of some conditions (the vegetation height and coverage on each layer and the climate factors as WI, CI, mean annual temperature, mean annual total precipitation etc.) in the Evergreen Broad-Leaved Forest,, Hong-Do island. The EBLF is classified into five units of vegetation (*Hedera rhombea-Machilus thunbergii* community (M-M comm.), *Castanopsis sieboldii* forest (*Machilus japonica-Castanopsis sieboldii* community; *Raphiolepis indica* var. *umbellata-C. sieboldii* community), community (Qa comm.), *Carpinus turczaninovii* community (Ct comm.), *Camellia japonica* stand (Cj stand)). The vegetation transition by CCA had high correlation with the height and coverage on each layer and the climate factors, and it did the succession (transition) that the M-M comm. (2010) from *Mallotus japonicus* community･*Machilus thunbergii* community･*Carpinus coreana* community (Cc comm.)･*Aucuba japonica* community (Aj comm.)･*Trachelos permum asiaticum* var. *intermedium-Quercus acuta* community (TQ comm.) (1986), the communities of *C. sieboldii* forest (2010) from Aj comm.･TQ comm.･*Raphiolepis umbellata-Camellia japonica* community (RC comm.) (1986), the Qa comm. (2010) from *Ardisia japonica-Castanopsis sieboldii* community (AC comm.) and TQ comm. (1986), the Ct comm. (2010) from Cc comm.･RC comm.･Aj comm.･*Quercus serrata* community and the Cj stand (2010) from AC comm. (1986). the height and coverage on each layer are also changed.

Key words : Phytosociology, Global warming, Vegetation change, Evergreen broad leaved forest

1. Introduction

Global warming means an increase in average temperature of Earth's surface. Since the late 1800's, the average temperature increased by about 0.4 to 0.8℃. Many experts expected that the average temperature will increase about 1.4-5.8℃ in 2100's. This increase means the rapid temperature changes compared to the changes in the past. The average temperature in the Korean Peninsula will rise an additional 3 to 4℃ by about 2100 (NASA, 2010).

The distribution of vegetation in Korea is so various on the influence of average maximum temperatures on warmest months, coldest months, mean annual total precipitation and seasonal distribution of precipitation. The mean annual precipitation is relatively much as about 1,200mm and concentrated in summer. The distribution of vegetation is affected by the

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temperature compared to the precipitation (Heo *et al.*, 2006).

It is significant that the study about characteristics of vegetation in Evergreen Broad-Leaved Forests (EBLF), because the more Global warming is in progress, the more EBLF extent will increase.

Hong-Do island is located on latitude 34° 41' and longitude 125° 12', 115km away from the port in Mok-po and 22km away from Heuksan-Do island (Fig. 1). The island was designated as Dadohaehaesang National Park in 1981 and No. 170 of a natural monument. Variety of rare plants about 540 species grow wild (Shinan-gun, 2010).

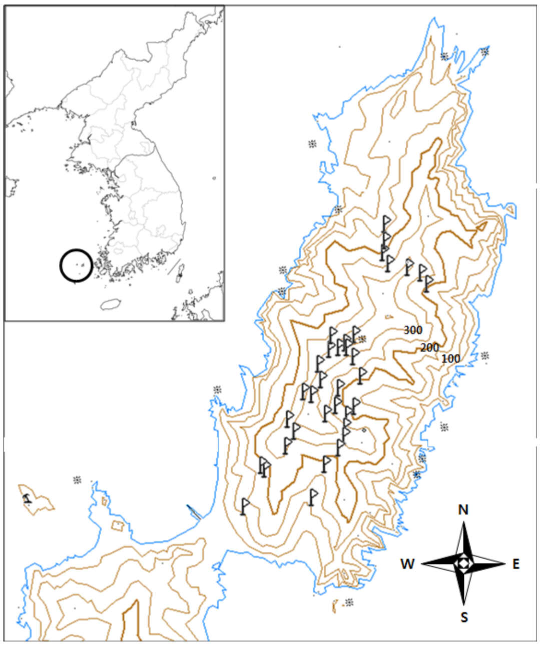

Fig. 1. Study areas in Hong-Do island.

Many studies have been conducted about the islands where the Evergreen Broad-Leaved Forest (EBLF) is distributed in Dadohaehaesang National Park (Oh and Cho, 1994; Kim and Oh, 1997), but it is rare recently that the phytosociological study about the EBLF in Hong-Do island and the study about changes of vegetation structure between the past and the present.

Our study examines the structure of present vegetation, the changes of vegetation structure over 25 years between 1986 and 2010, and what kinds of conditions had an effect to the changes, in Hong-Do island. This is useful as the basic data for a conservation and a protection of typical EBLF.

2. Materials and Methods

2.1. Environmental status of study site

The change of mean annual temperature in the study site (average altitude: 247.4 m) over 50 years from 1960 to 2009 was confirmed after applying the air temperature lapse rate (-0.55℃/100 m) by Kira (1948) to the annual mean temperature data of Mokpo weather station (Korea meteorological administration, 2010). We also confirmed the changes of Warmth Index (WI) and Coldness Index (CI) in the study site over 50 years. The EBLF and the southern part of Deciduous Broad-Leaved Forest (DBLF) are usually placed on the CI over -10℃ and in the one of forest on the WI from 90℃ to 105(100)℃ in the warm-temperate zone (Yim and Kira, 1975).

The mean temperature of about 0.52℃ increased in the study site over last 50 years (Fig. 2). The WI had increased from about 101.21℃ to 104℃. This range of WI belongs to the southern part of warm-temperate DBLF. The study site had therefore been

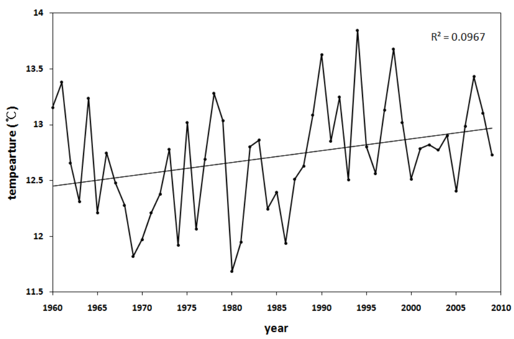

Fig. 2. Temperature change of study area in Hong-Do island over 50 years Mean altitude of research areas: 247.4 m.

warm-temperate broad-leaved forest over 50 years. The CI had increased from about -11.78℃ to -8.29℃. the study site have belonged to the condition of EBLF in the warm-temperate zone since around 1985. The present forest therefore belongs to the EBLF in the warm-temperate zone, and the past one was the southern part of DBLF in the warm-temperate zone. A typical EBLF in the warm-temperate zone can be formed in this study site (Barbour *et al*., 1980).

2.2. Research and Analysis Method

2.2.1. Study site and vegetation classification

We researched the new EBLF which is not researched before and the other EBLF which was researched 25 years ago for the comparative study about vegetation transition between 1986 and 2009. We carried out this study for 1 years from August, 2010 to March, 2011. We selected total 35 quadrates in typical EBLF, and 23 quadrates of 35 quadrates were installed on the points researched 25 years ago (Memorial foundation of prof. Kim Chul Soo's 60 birthday, 1990) for the confirmation of vegetation transition. Fig. 1 shows the location of quadrates and topography of the study site.

We chose the quadrates between 10 m x 10 m and 15 m x 20 m on homogeneous stands, based on the minimum extent showing representatives of the each vegetation type in the study site, and investigated the dominance · sociability of each appearance species in each stand according to the phytosociological vegetation research method (Braun-Blanquet, 1964). The scientific name of component species were based upon a korean plant names index (The Office of Korean Forestry, 2007).

2.2.2. Classification and ordination analyses and correlation between vegetation and environmental factors for vegetation transition

The classification and ordination analyses were analyzed with a Cluster Analysis (Euclidean distance) by PC-ORD 4.41 (McCune and Mefford, 1999) after the dominance and sociability by the phytosociological method converted to the quantification (+→0.1, +.2 →0.5, 1.1→2.5, 2.1/1.2→2.5, 2.2→15, 2.3→26.25, 3.2→37.5, 3.3→37.5, 4.3/3.4→50, 4.4→62.5, 4.5/5.4 →75, 5.5→87.5). The quantification method in this study is for the reflection of a delicate difference according to both of the dominance and sociability and the influence by sociability for a community formation, although general quantification method reflects dominance values (Van der Maarel, 1979; Ahn *et al*., 2007; Song *et al*., 2009).

For the confirmation of the change of species composition and quantification between the present research data and the past research data (Memorial foundation of prof. Kim Chul Soo's 60 birthday, 1990) over 25 years, we also analyzed a correlation between the vegetation transition and the environmental and structural conditions over 25 years by Canonical Correspondence Analysis (CCA). The environmental and structural condition involved: a height and a coverage on each layer, a altitude, a slope inclination, an slope direction, and climatic conditions. The environmental conditions were measured with Clinometer (Kanayama Co. Japan) and GPS (Garmin, Oregon-300). The climatic conditions are the mean data of WI, CI, annual temperature and total precipitation between 1986 and 2009 at the data of Korea Meteorological Administration (KMA, 2010). The dominant species '*Castanopsis cuspidata*' in the past data was modified to *Castanopsis sieboldii*, based on vegetation data of the Environmental Geographical Information Service (EGIS, 2010) by Ministry of Environment in South Korea.

3. Result and Discussion

3.1. Phytosociological classification of EBLF in Hong-Do island

The EBLF in Hong-Do island is classified into four vegetation types such as the composition of dominant species in canopy according to the phyto-sociological method and the cluster analysis (Table 1, Fig. 3). The four vegetation types are a *Hedera Rhombea- Machilus thunbergii* community (unit: I), a *Castanopsis sieboldii* forest (Ⅱ; Ⅱ-1: *Machilus japonica-C. sieboldii* community, Ⅱ-2: *Raphiolepis indica* var. *umbellata-C. sieboldii* community), a *Quercus acuta* community (Ⅲ), a *Carpinus turczaninovii* community (Ⅳ) and a *Camellia japonica* stand (Ⅴ). The *H. rhombea-M. thunbergii* community and the *C. sieboldii* forest are classified into subunits (Table 1), but the subunits are not classified clearly in the cluster analysis (Fig. 3).

3.1.1. *Hedera rhombea–Machilus thunbergii* community (Ⅰ)

Differential species: *H. rhombea, Morus australis, Arisaema amurense* for. *serratum*

This community is distributed on 155-307m altitude and most of NW slope except for SE(HD12), SW(HD24) and NE(HD33). The dominant species is *M. thunbergii* and the differential species are confirmed with *H. rhombea, M. australis, A. amurense* for. *serratum*.

A *M. thunbergii* forest is classified as two association types (Polysticho-Perseetum thunbergii Suz.-Tok. et Wada 1949 and Arisaemato ringentis-Perseetum thunbergii Miyawaki et al. 1971) in the class (Camellietea japonicae Miyawaki et Ohba 1963), Japan (Miyawaki *et al.*, 1983). The character species in two associations of Japan, *Polystichum polyblepharum* var. *polyblepharum*, *Piper kadsura, Zelkova serrata*, *Aphananthe aspera*, *Cornus controversa*, *Ficus oxyphylla*, *M. thunbergii*, *Cinnamomum japonicum*, do not correspond with the differential species of this community except for *A. aspera* in the subunit of this community(BGPlant, 2010). Some of the character species appear in the other community units in this study. *M. thunbergii* could not form a community unit according as *M. thunbergii* appeared at the high constancy numerical value in the other area, Hong-Do island. *M. thunbergii* is the only differential species of *M. thunbergii* forest against other forest and community units in South Korea, though the differential species are valuable for the classification against the other community units in only Hong-Do island. *M. australis* in the differential species is not the suitable species as the differential species of *M. thunbergii* forest to separate against other vegetation units in Korea though the species appears in the most of *M. thunbergii* stands, because the species is distributed in South Korea, western Japan and Manchuria and Sakhalin in the cold temperate zone (Lee, 1996; Takahashi *et al.*, 1991). *A. amurense* for. *serratum* is not also suitable species because the species is distributed in South Korea, China and a cold temperate zone (Lee, 1996). *H. rhombea* is not also suitable differential species of *M. thunbergii* forest, because the species can be distributed usually in an warm-temperate zone although the species is distributed in the subtropical zone to the ecotone between the warm-temperate and the cold-temperate zones (Lee, 1996; Song, 2004). *M. thunbergii* is therefore the differential species in this community against the other communities in only Hong-Do island, because the species appeared with high frequency and dominance values in the other community units of an EBLF, southern South Korea (Kim *et al.*, 1989; CHOLLANAM-Do, 1995; Lee and Ahn, 2011a; Lee *et al.*, 2011).

The structure of tree layer is composed of the average vegetation height of 12.33 m and vegetation coverage of 86.11%. The Evergreen Broad-Leaved Species (EBLS) as *M. thunbergii* and *Neolitsea sericea* and the Deciduous Broad-Leaved Species (DBLS) as *Mallotus japonicus* are found at the high frequencies over 70%. The EBLS as *C. sieboldii*, *Q. acuta*, *Euscaphis japonica*, *Neolitsea aciculata* and the DBLS as *Ilex macropoda*, *Styrax japonica*, *Ficus erecta*, *Cerasus sargentii*, *A. aspera* and *Acer pictum* subsp. *mono* are found. *M. thunbergii* dominates in the most of canopy vegetation, and the dominances and sociabilities of *M. japonicus* and *N. sericea* are comparatively low as '+' to '2.3'. The structure of subtree layer is composed of the average vegetation height and coverage of 9.33 m and 20%. *C. japonica* and *F. erecta* dominate at the frequencies over 60% and the dominances · sociabilities of maximum '3.3'. It is also found that the EBLS as *Dendropanax morbiferus*, *M. thunbergii*, *N. sericea*, *M. japonica*, *N. aciculata*, *Daphniphyllum macropodum*, etc. belong to typical species in the EBLF of Korea and the Camellietea japonicae (Miyawaki *et al.*, 1983; Fujiwara, 1981) The DBLS as *M. australis*, *C. sargentii*, etc. at the low frequencies and dominances. The structure of shrub layer is composed of the average vegetation height and coverage of 6.11 m and 35%. The structure of herb layer is composed of the average vegetation height and coverage of 0.53 m and 19.44%. It dominates at the high frequencies over 50% and the dominances · sociabilities of maximum '2.3' that the EBLS as *K. japonica*, *T. asiaticum*, *C. japonica*, *H. rhombea*, *Ardisia japonica*, *N. sericea* and the herb species as *Dryopteris erythrosora*, *Ophiopogon japonicus* and *Arisaema ringens*. *D. morbiferus*, *M. thunbergii*, *Dryopteris hondoensis*, *Stauntonia hexaphylla*, *Dryopteris lacera*, *Ophiopogon jaburan*, *Callicarpa japonica* and *M. japonicus* are found at next high frequencies and the low dominances · sociabilities. The distribution of *O. jaburan* is also confirmed in this study, according as some data show that the species distributed in Southern Korea (Satake *et al.*, 1988) and Geoje-Do island, Jeju-Do island and Mt. Wolchul-san, in South Korea (Lee, 1996).

This community is classified into the subunits based on *L. japonica*, *I. macropoda*, *D. lacera*, *Viburnum odoratissimum* var. *awabuki*, *Viburnum dilatatum*, *Ligularia fischeri*, *Galium kinuta*, *Sanicula chinensis*, *A. aspera* and *A. arguta* except for the differential species. The subunits are a *D. lacera-L. japonica* group, a *A. aspera* group and a typical group (1).

The *D. lacera-L. japonica* group is composed of *L. japonica*, *D. lacera* and *I. macropoda* in most of stands, *V. odoratissimum* var. *awabuki* in HD07 stand and *V. dilatatum*, *L. fischeri*, *G. kinuta* and *S. chinensis* in HD06 stand. *L. japonica* is distributed in the warm-temperate and subtropical zones, Korea and Japan (Kitamura and Murata, 1987b; Lee, 1996). This species can be valuable for the confirmation of the separation between the warm-temperate and the cold-temperate zones and the extents of vegetation distribution and transition in the warm-temperate and subtropical zones, according to the distribution and appearance of this species. *I. macropoda* is distributed in all parts of Japan except for the Ryukyu Archipelago in the subtropical zone and in the temperate and warm-temperate zones, Korea (Kitamura and Murata, 1987a; Lee, 1996).

This community will be changed and maintained to the typical and natural *M. thunbergii* matured forest if there are no artificial influence and the temperature to rise by global warming, according as this *M. thunbergii* forest with average 12.33 m and maximum 15 m is not close to the natural matured forest below the dominant species' height of about 20 m and maximum 30 m (Lee, 2003; Hayashi, 1986), this forest is the one of climatic climax forest (Miyawaki, 1989). This community will be formed and maintained as the characteristic community structure in only Korea according to the differences of character and differential species with the association structure of *M. thunbergii* forest in Japan (Miyawaki *et al.*, 1983).

3.1.2. *Castanopsis sieboldii* forest (*Machilus japonica–Castanopsis sieboldii* community; *Raphiolepis indica* var. *umbellata–Castanopsis sieboldii* community)

3.1.2.1. *M. japonica-C. sieboldii* community (Ⅱ-1)

Differential species: *M. japonica, K. japonica, A. ringens, Arachniodes aristata*

This community is distributed on 118-306 m altitude and slopes of NW (4 stands), SE (3 stands), NW (1 stand), NE (1 stand), W (1 stand) and plate land (1 stand). The dominant species is *C. sieboldii* and the differential species are confirmed with *M. japonica, K. japonica, A. ringens* and *A. aristata.*

This community falls under a high climatic influence compared to the *R. indica* var. *umbellata-C. sieboldii* community (Ⅱ-2) according to the differential species. The differential species are also found in the *M. thunbergii* forest as a climatic climax forest. The Korean *C. sieboldii* forest is confirmed as Ardisio-Castanopsietum sieboldii ass. according to the vegetation system of Japan (Miyawaki *et al.*, 1983; CHOLLANAM-DO, 1995; Lee and Ohno, 2009; Lee *et al.*, 2009; 2010b). The character species in Ardisio-Castanopsietum sieboldii are *C. sieboldii* · *Quercus salicina* · *Osmanthus heterophyllus* · *Damnacanthus indicus* · *Cymbidium goeringii* · *Podocarpus macrophyllus* as the differential species in Polysticho-Perseetum thunbergii and *F. oxyphylla* · *C. japonicum* · *Dryopteris pacifica* · *E. macrophylla* as the differential species in Quercetum myrsinaefoliae (Fujiwara, 1981). These species are different from the differential species in this community. *C. goeringii* is the differential species in the subunit of *C. sieboldii* typical community. *F. oxyphylla* is the common species of *Q. acuta* and *C. sieboldii* forests. *C. japonicum* and *D. pacifica* are the species of climax forest in the EBLF.

A. aristata is the character species in a Arachniodo-Castanopsietum sieboldii, and this association is formed on fine soil conditions, and the Ardisio-Castanopsietum sieboldii is formed on the comparatively dry soil condition (Fujiwara, 1983).

A total of 71 species is recorded in 11 stands. The Hierarchical structure in the stands is formed of 4 layers as a tree, a subtree, a shrub and a herb layers except for HD14 stand as 3 layers without a subtree layer.

The structure of tree layer is composed of the average vegetation height and coverage of 12.64 m and 80%. The EBLS as *C. sieboldii*, *Q. acuta*, *N. sericea*, *M. thunbergii*, etc. are found with the high frequencies over 50%. The EBLS as *N. aciculata*, *M. japonica* and *Litsea coreana* and the DBLS as *M. japonicus*, *Rhus succedanea* and *Ailanthus altissima* are found. the EBLS including *C. sieboldii* dominates in the most of this community, and at the frequency, dominance and sociability of *M. japonicus* are comparatively high as 20% and 1.1 among the DBLS. The structure of subtree layer is composed of the average vegetation height of 9.9 m and vegetation coverage of 19.5%. The Korean EBLS in an warm-temperate zone and the character and differential species of Camellitea japonicae as *N. sericea*, *D. morbiferus* and *C. japonica* dominate with the high frequencies over 46% and the dominances · sociabilities of maximum '3.3'. It is also found that the EBLS as *D. macropodum*, *T. asiaticum*, *S. hexaphylla*, *N. aciculata*, *E. japonica*, *M. thunbergii*, *Q. acuta*, etc. and the DBLS as *S. japonica*, *F. erecta*, etc.. The EBLS as *C. japonica*, *D. morbiferus*, *M. thunbergii*, *L. japonicum*, *C. sieboldii*, *E. japonica*, *N. aciculata*, *M. japonica*, *Aucuba japonica*, *N. sericea*, etc. in the warm-temperate zone and the DBLS as *F. erecta*, dominate at high frequencies over 70% and the dominances and sociabilities of maximum '3.3'. The structure of herb layer is composed of the average vegetation height and coverage of 0.56 m and 16.64%.

This community is classified into the subunits based on *D. caudipinna*, *D. nipponensis* and *C. lenta* except for the differential species. The subunits are a typical group (1), *D. nipponensis-K. japonica* group and *C. lenta* group (1).

The typical group is composed of the differential species of low frequency and dominance compared to the other subunits, without the one of differential species as *K. japonica*. The *D. nipponensis-K. japonica* group is only composed of *K. japonica* and *D. nipponensis* as the differential species. *K. japonica* is distributed in the warm-temperate and subtropical zones in East Asia and the Korean warm-temperate zone as Jeju-Do island and Cholla prefecture (Lee, 1996), and *D. nipponensis* is distributed in Japan, and Ulleung-Do and Jeju-Do islands and Cholla prefecture in Korea (Ikeda, 2006). The typical EBLF therefore have been structured in the study sites of this subunit. *C. lenta* as the only differential species in the *C. lenta* group is the typical component species distributed in the warm-temperate, tropical and subtropical zones as Japan, China, India and Indonesia (Satake *et al.*, 1988) and in the EBLFs in Jeju-Do island and Wan-Do island, Korea. This species is not correspond to the differential and character species of the vegetation system of Japan. This community and subgroup is the one of endemic vegetation units in only Hong-Do island according to the characteristics of *C. lenta* as a differential species(Kim *et al.*, 1989)

3.1.2.2. *R. indica* var. *umbellata-C. sieboldii* community (Ⅱ-2)

Differential species: *R. indica var. umbellata, Fraxinus sieboldiana, Hemerocallis fulva* var. *fulva, Hosta longipes* var. *longipes*

This community is distributed on 100-225 m altitude and slopes of NW (2 stands), SE (2 stands), NW (1 stand) and NE (1 stand). The dominant species is *C. sieboldii* and the differential species are confirmed with *R. indica var. umbellata* · *F. sieboldiana* in the shrub layer and *H. fulva* var. *fulva* · *H. longipes* var. *longipes* · *R. indica var. umbellata* · *F. sieboldiana* in the herb layer. According to the composition of differential speices, this community is influenced relatively by soil compared to the *M. japonica-C. sieboldii* community. All of the species appear in *C. turczaninovii* forest as the edaphic climax forest in the warm-temperate zone.

There is no corresponding species between the character species in Ardisio-Castanopsietum sieboldii ass. (Miyawaki *et al.*, 1983) and the differential species in this community. *C. goeringii* is the only differential species for the classification of a subunit among the character species. according as *R. indica var. umbellata* is distributed in the warm-temperate and subtropical zones as Japan, Taiwan and Jeju-Do island·southern parts of South Korea (Lee, 1996; Song, 2004). the research points of the subunit are included in the typical EBLF. *H. longipes* var. *longipes*, *F. sieboldiana* and *H. fulva* var. *fulva*, distributed on relatively barren soil conditions, are distributed.

A total of 82 species is recorded in 5 stands. The Hierarchical structure in the stands is formed of 4 layers as a tree, a subtree, a shrub and a herb layers except for HD35 stand of 3 layers without a subtree layer. The structure of tree layer is composed of the average vegetation height and coverage of 9.2 m and 83%. The EBLS as *Q. acuta*, *D. macropodum*, *Ilex integra*, *D. morbiferus*, *M. thunbergii*, *N. aciculata*, etc. appears, but there is no DBLS. This community has the relatively low vegetation height because of the edaphic restriction compared to the *M. japonica-C. sieboldii* community influenced by climatic influences. The structure of subtree layer is composed of the average vegetation height and coverage of 9m and 5%. It appears that the EBLS as *Q. acuta*, *N. sericea*, etc. and the DBLS as *Euonymus oxyphyllus*, *C. japonica* var. *luxurians*, etc., which is distributed in the warm-temperate zone. The structure of herb layer is composed of the average vegetation height and coverage of 0.5 m and 40%.

This community is classified into the subunits based on *C. lenta*, *P. densiflora*, *Disporum smilacinum*, *C. goeringii*, *Dryopteris fuscipes*, *Polygonatum involucratum*, *Mitchella undulata*, etc. except for the differential species. The subunits are a *C. lenta* group (2) and a *P. densiflora* group (1).

The *C. lenta* subgroup (2) is under the relatively low edaphic influences, according as it appears as differential species in this group that *C. lenta* which is the differential species of the subgroup in *M. japonica-C. sieboldii* community which influenced relatively more by climatic conditions. There is especially no species which can show the characteristics of edaphic influence. The *P. densiflora* group is the subunit on the relatively edaphically influenced conditons compared to the climatic influences. The differential species as *D. smilacinum*, *C. goeringii*, *D. fuscipes*, *P. involucratum*, *M. undulata*, etc. for the classification of this subunit apprear. those can be distributed on the edaphic influences as well as the climatic influences in the warm-temperate zone. The result of two subunits shows the difference of vegetation development by edaphic influences within this community. The *P. densiflora* group especially is placed under the succession from *P. densiflora* forest influenced by edaphic conditions to *C. sieboldii* forest influenced by climatic conditions.

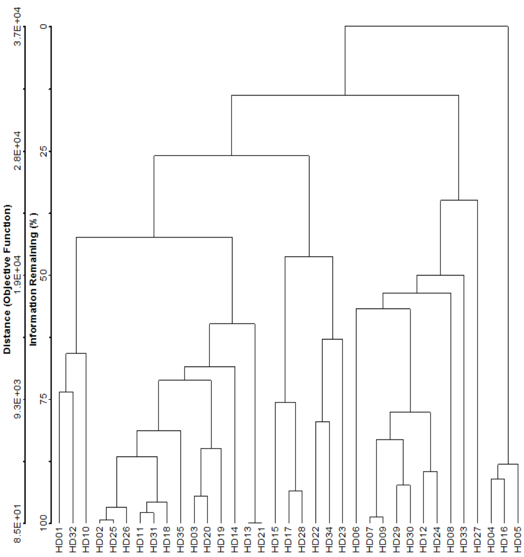

Fig. 3. Cluster analysis of study stands Linkage method: GROUP AVERAGE Distance measure: Euclidean (Pythagorean).

This community will be maintained to the typical and natural *C. sieboldii* matured forest if there are no artificial influence and the temperature to rise by global warming, according as this *C. sieboldii* forest with average 11.56 m and maximum 19 m is close to the natural matured forest below the dominant species' height of about 15 m and maximum 30 m (Hayashi, 1986; Lee, 2003; Song, 2004), This forest is the one of climatic climax forest (Miyawaki, 1989), The climate condition in this site belongs to the warm-temperate zone lately and the average height of the one part of *R. indica* var. *umbellata-C. sieboldii* community under edaphic influences is lower as about 6m than the other parts of other community.

3.1.3. *Quercus acuta* community (Ⅲ)

Differential species: *Q. acuta, Callicarpa japonica, D. indicus, Liriope spicata, A. altissima* etc.

This community is distributed on 250-350 m altitude and slopes of NW (1 stand), SW (1 stand), SE (1 stand) and NE (3 stands). A dominant species is *Q. acuta. Q. acuta* and *D. indicus* have only meaning as the differential species of *Q. acuta* community, even if differential species are the DBLS as *A. altissima* in tree and shrub layers, *Callicarpa japonica,* and *Carex ciliatomarginata* in shrub or herb layers, and the EBLS as *D. indicus, L. spicata* in shrub or herb layers. *D. indicus* is the character species of Ardisio-Castanopsietum sieboldii Suz.-Tok. 1952 in the Japanese vegetation system (Fujiwara, 1981), but this species does not influence to the vegetation classification for *C. sieboldii* forest, even if it is appeared at the typical group in *M. japonica-C. sieboldii* community and the *C. japonica* stand. *L. spicata* and *Callicarpa japonica* are the species appearing all around Korea and *A. altissima* is also the species that is possible to be planted and grow wild all around Korea. The tree species is therefore not useful for the differential or character species of *Q. acuta* forest to be differentiated against all kinds of vegetation types in Korea (Chang *et al*., 1988) .

A total of 77 species is recorded in 6 stands. The

Hierarchical structure in the stands is formed of 4 layers as a tree, a subtree, a shrub and a herb layers except for one stand (HD15).

The structure of tree layer is composed of the average vegetation height and coverage of 10.67 m and 83.33%, and *C. sieboldii* is found at the dominances and sociabilities of maximum '3.3'. *M. japonicus* as the DBLS in the tree layer is found at the frequency of 50%, and can be distributed from the subtropical zone to the ecotone between the warm-temperate and the cold temperate zones according to the distribution data (Lee, 1996; Kitamura and murata, 1987a) of Korea, Japan and Taiwan, even if the data (Kitamura and murata, 1987a) mentioned that this species is only distributed in the warm-temperate zone. The structure of shrub layer is composed of the average vegetation height and coverage of 5.5 m and 41.67%. The typical EBLS as *Q. acuta*, *C. japonica*, *E. japonica*, *L. japonicum*, *C. sieboldii*, *D. morbiferus* and *M. thunbergii* in the warm-temperate zone are dominant at the high frequencies of over 80% and the dominances · sociabilities of maximum '3.3' in the shrub layer.

This community will be changed and maintained to the typical and natural *Q. acuta* matured forest if there are no artificial influence and the temperature to rise by global warming, according as this *Q. acuta* forest with average 10.67m and maximum 12 m is not close to the natural matured forest below the dominant species' height of about 20m and maximum 25m (Lee, 2003; Hayashi, 1986; Kitamura and Murata, 1987b).

Some studies informed that a *C. sieboldii* forest was distributed around 200m altitude and a *Q. acuta* forest was distributed around 500m altitude in Korea (Lee and Ohno, 2009), and a *C. sieboldii* forest was usually distributed in lower altitude than a *Q. acuta* forest (Lee and Ohno, 2009). In Korea, a *Q. acuta* forest at Duryun-San and Dalma-San (mountains) was distributed between 116 m and 289 m altitudes (Lee and Ahn, 2011a; *Lee et al.*, 2011), and a *Q. acuta* forest in Mt. Wolchul-San appeared between 150m and 330m altitudes (Shim, 2006; Lee and Ahn, 2011b).

The extent of *Q. acuta* forest will decrease and the decreased extent will be succession toward *C. siebolldii* forest, according to the temperature to rise by global warming and the results of distribution by the studies meaning that the more temperature is high in any area, the more *Q. acuta* forests usually appear in high altitude, and *C. sieboldii* forests are distributed until relatively high altitude compared to that of low temperature. Especially, the most of islands in Korea except for Jeju-Do island are influenced by the oceanic climate and smaller extent than Japan. It is found at high frequencies, dominances and sociabilities that the warm-temperate species such as *D. erythrosora*, *Aucuba japonica*, *N. aciculata*, *F. erecta*, *D. hondoensis* and *F. erecta* as common species of the climatic climax forest and the EBLF in the warm-temperate zone

3.1.4. *Carpinus turczaninovii* community (Ⅳ)

Differential species: *Rubus corchorifolius, Melampyrum roseum* var. *japonicum, Miscanthus sinensis* f. *purpurascens, Oplismenus undulatifolius* var. *undulatifolius, Clerodendrum trichotomum, Ostericum praeteritum, Cocculus orbiculatus, Fraxinus rhynchophylla, Vitis coignetiae, Lindera obtusiloba, Rhus javanica* var. *chinensis, Hepatica nobilis* var. *japonica* f. *variegata, Dendranthema boreale, Quercus serrata, Rhododendron mucronulatum* var. *mucronulatum, Rhaphiolepis indica* var. *integerrima*

This community is distributed in altitude 330-350m, and slope of NE (1 stand). The dominant species is *C. turczaninovii*, the differential species are *Q. serrata* on the tree layer, *R. indica* var. *integerrima* on the subtree layer and *R. corchorifolius*, *Clerodendrum trichotomum*, *Lindera obtusiloba*, *R. javanica* var. *chinensis*, *F. rhynchophylla*, *R. mucronulatum* var.

mucronulatum, *C. orbiculatus*, *M. roseum* var. *japonicum*, *M. sinensis* f. *purpurascens*, *O. undulatifolius* var. *undulatifolius*, *H. nobilis* var. *japonica* f. *variegata*, *O. praeteritum*, *D. boreale* and *V. coignetiae* on the shrub and/or herb layers.

A total of 80 species is recorded in 3 stands. The Hierarchical structure in the stands is formed of 3 layers as a tree, a shrub and a herb layers except for one stand (HD16) with 4 layers.

The structure of tree layer is composed of the average vegetation height and coverage of 5m and 56.67%, and *C. sieboldii* is found at high frequency and dominance besides the dominant species *C. turczaninovii*. *C. turczaninovii* does not appear on the tree layer in this stand and *P. densiflora* appears as the coverage of 5%. The structure of subtree layer is compose of the average vegetation height and coverage of 3 m and 85%, and *C. turczaninovii* dominates at the dominance and sociability of '4.4' in only HD16 stand. *R. indica* var. *integerrima*, *C. japonica*, *A. pictum* subsp. *mono*, etc. appear. The community have been an succession from the *P. densiflora* forest to the *C. turczaninovii* forest, because *C. turczaninovii*, which dominates on the tree layer in the other communities, dominates in the subtree layer, and *P. densiflora* remains at low coverage in the tree layer. The structure of shrub layer is composed of the average vegetation height and coverage of 2 m and 26.67%, and the DBLS as *M. japonicus*, *E. oxyphyllus*, *C. japonica* var. *luxurians*, *R. corchorifolius* and *R. javanica* var. *chinensis* appears at the high frequencies. The distribution of the most species is not subject to restriction in the warm-temperate zone except for *C. japonica* var. *luxurians* and *R. corchorifolius*. The structure of herb layer is composed of the average vegetation height and coverage of 0.5 m and 80%, and *T. asiaticum* dominates at the dominances and sociabilities over '4.3' in the most of this community.

This community will be succession to the one community unit of *C. sieboldii* forest with relatively high edaphic influences according to the appearances of the differential species as *R. indica var. umbellata*, *H. fulva* var. *fulva* and *H. longipes* var. *longipes* in *R. indica* var. *umbellata-C. sieboldii* community, the character and differential species of Camellitea japonicae and the *C. sieboldii,* according as this *C. sieboldii* forest with average 5m and maximum 5m is close to the natural matured forest with average 5m based on the growth possibility of *C. turczaninovii* selected as height 5m by the Makino (1989) as 2-3 m, the Hayashi (1986) as 3-4 mm.

3.1.5. *Camellia japonica* stand (Ⅴ)

This community is distributed in altitude 226m, and slope of NW.

The dominant species is *C. japonica*, and there is no differential species.

A total of 32 species is recorded in one stand. The Hierarchical structure in the stand is formed of 4 layers as a tree, a subtree, a shrub and a herb layers. *C. japonica* on the subtree layer appears at the high dominance・sociability of '4.3'.

The structure of tree layer is composed of the average vegetation height and coverage of 11m and 85%. It appears that the character and differential species of Camellitea japonicae as *N. sericea*, *C. sieboldii*, etc. and the DBLS as *R. succedanea*, *F. erecta*, etc. in the warm-temperate zone. The structure of subtree layer is composed of the average vegetation height and coverage of 8m and 70%. *C. japonica* dominates and *M. japonica*, *F. erecta*, *N. sericea*, *D. macropodum*, etc. are also appear. The structure of shrub layer is composed of the average vegetation height and coverage of 3m and 15%, and the most of species appear at the dominance・sociability of '1.2'. the most of species are the component species of the typical Korean EBLF as *M. japonica*, *Aucuba japonica*, *N. sericea*, *D. morbiferus*, *M. thunbergii*, etc. The structure of herb layer is composed of the average vegetation height and coverage of 0.5 m and 15%, and the most of species appear at the dominance · sociability of '1.2'. the most of species are *H. rhombea*, *N. sericea*, *T. asiaticum*, *C. japonica*, *K. japonica*, *D. erythrosora*, *M. thunbergii*, etc. in the warm-temperate zone(Kim and Oh, 1997).

3.2. Ordination analysis and correlation between vegetation and environmental factors for vegetation transition

3.2.1. Hierarchical cluster analysis of present vegetation

The correlations among stands are comprised in the dendrogram according to the cluster analysis and the level (Fig. 3). Stand group continues to be divided into 34 levels, but all of the 34 levels does not correspond adequately to the phytosociological classification(Pilou, 1969).

At the minimum 4th level (2.4103E+04), the stand group corresponds to the phytosociological classification on the forest or community levels. The detail levels over 4th level are unmeaningful for the classification of communities.

At the classification of the first level (3.7068E+04), 2 groups are classified. the one group is the *C. turczaninovii* community as the one of the edaphic climax forest (DBLF) in the warm-temperate zone and the other group is the EBLF including the climatic climax forests in the warm-temperate zone. the existences of the differential species in *C. turczaninovii* community and the elements of climatic climax forest influence to the classification on the first level.

At the classification of the second level (3.1924E+04), 2 groups are classified. the first group is the *C. sieboldii* and *Q. acuta* forests, and the second group is the *M. thunbergii* forest and *C. sieboldii* stand. The Quantitative values of *C. sieboldii*, *Q. acuta* and *M. thunbergii*, and the differential species in *M. thunbergii* forest and the elements of *Q. acuta* and *C. sieboldii* forests have an influence on the classification of the 2 groups.

At the classification of the third level (2.7431E+04), the first group in the second level is divided into 2 groups. The first group is the *C. sieboldii* forest and the second group is the *Q. acuta* community. The classification of the group is correlated to the differences of the Quantitative values of *C. sieboldii* and *Q. acuta*, the existences of differential species in *Q. acuta* community and *C. sieboldii* forest.

At the classification of the 4th level (2.4103E+04), the second group in the second level is divided into 2 groups. The first group is the *H. rhombea-M. thunbergii* community as the *M. thunbergii* forest and the second group is the *C. japonica* stand. The classification of the group is correlated to the differences of the differential species of *M. thunbergii* community as *Q. acuta, A. ringens,* etc.

Over the 5th level (2.1356E+04), any species which do not influence the classification of communities are correlated to the unstable classification which does not correspond to the physociological classification. That is to say, the differential and character species in each subunit and community and the elements related to the EBLF do not have influences on the more detail classification over the 5th level. Some stands in over the 5th level have the high correlation at each other in the same level from 1st to 4th levels. that is influenced by the consensus of appearance species.

3.2.2. Correlation between environment factors etc. and vegetation transition over 25 years with CCA

It analyzed that the correlation between the vegetation transition and the changes of environment factors and forest layer structures over 25 years with CCA (Fig. 4; Table 1).

3.2.2.1. *M. thunbergii* forest

The vegetation of HD06 and HD07 stands of *D. lacera-L. japonica* group in the *H. rhombea-M. thunbergii* community is changed from the past study stands of no. 63 and 113 according to the changes of

Table 1. Synthetic table of the forest communities in the study area

Serial number		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
releve number (1)*		HD 06	HD 07	HD 09	HD 08	HD 29	HD 30	HD 12	HD 24	HD 33	HD 11	HD 26	HD 18	HD 32	HD 02	HD 03	HD 31	HD 19	HD 20	HD 25	HD 14	HD 35	HD 13	HD 21	HD 10	HD 01	HD 22	HD 34	HD 28	HD 15	HD 23	HD 17	HD 04	HD 05	HD 16	HD 27
releve number (2)		63 112 113	63 112 113	65 114 115	65 114 115	104	-		29 30 31	101	-	-	-	35	-	105	-	35	34	-	41	-	-	34	61 110 111	-	40	-	46	-	28	47 103	48	49 51 106	-	45
T1 (m)		12	12	12	12	11	11	15	13	13	13	12	11	12	14	11	12	19	11	14	10	11	10	6	9	10	12	12	10	7	12	11	5	5	5	11
T2 (m)		8	10	9	10	9	8	10	10	10	10	10	7	10	11	9	10	12	9	11	-	9	-	10	10	8	-	9	7	-	3	8	-	-	-	-
S (m)		5	7	6	6	6	4	6	8	7	6	8	5	7	8	3	8	8	6	8	6	6	6	4	6	6	6	7	5	3	7	5	3	2	1	3
H (m)		0.5	0.5	0.5	0.5	0.8	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.8	0.5	0.5	0.8	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.8	0.5	0.8	0.5	0.5	0.5	0.5
T1 (%)		90	95	85	85	85	80	80	90	85	85	75	85	80	85	80	75	80	80	80	75	90	75	90	75	85	85	85	80	80	80	90	85	80	5	85
T2 (%)		15	5	10	5	20	60	20	25	20	10	15	10	5	10	70	10	30	20	15	-	5	-	10	15	20	-	10	15	-	85	70	-	-	-	-
S (%)		40	35	35	25	50	25	30	40	35	35	40	40	30	35	20	30	35	35	40	35	35	35	40	35	40	30	40	45	60	35	40	35	35	10	15
H (%)		40	20	20	20	15	10	10	20	20	15	15	15	40	15	10	15	20	8	15	15	15	15	30	80	60	60	35	30	80	20	50	85	85	70	15
Slope direction		N 36 W	N 22 W	N 36 W	N 52 W	N 60 W	N 34 W	S 84 E	S 50 W	N 32 E	S 36 E	S 80 W	S 16 W	S 52 E	W	N 60 W	S 44 E	S 10 W	N 66 E	S 12 W	-	N 78 W	S 66 E	N 60 E	S 40 E	N 84 W	N 12 E	N 52 E	N 78 W	N 28 E	S 26 W	S 8 E	S 70 E	S 70 E	S 22 E	N 68 W
Slope inclination		27	25	28	34	27	34	23	24	30	30	25	35	35	28	25	32	33	38	26	0	28	30	41	30	26	10	37	38	5	32	37	40	40	39	32
Altitude (m)		275	226	189	155	307	278	206	216	247	239	118	273	230	165	306	299	198	190	170	248	101	249	240	285	181	270	298	350	325	250	296	330	350	332	266
Quadrate size (m^2)		300	225	225	225	150	225	300	225	225	300	100	300	200	300	225	225	300	225	225	225	225	225	150	100	225	225	225	225	120	225	150	100	100	100	150
No. of species		49	26	23	37	32	29	24	24	23	24	21	26	28	33	29	29	28	32	24	30	23	40	49	32	48	29	33	33	40	30	28	48	43	36	32
Units**		*Ⅰ									Ⅱ-1											Ⅱ-2					Ⅲ						Ⅳ			Ⅴ
Subunits (1)		a				b		c			d				e					f		g	h													
Differential species of *M. thunbergii* forest																																				
Machilus thunbergii	T1T2SH	4.4	4.4	4.4	5.4	4.3	4.3	5.4	4.4	3.3	1.2	+.2	1.2	1.1	1.1	2.2	1.1	1.2	1.2	1.2	1.1	2.2	1.1	1.2	1.1	2.2	+.2	+.2	1.2	+	1.2	+	·	·	·	+.2
Hedera rhombea	SH	2.2	1.2	2.2	1.2	+.2	+	+.2	·	·	·	+	·	·	+	·	·	·	·	+.2	·	·	·	·	·	·	·	+	·	1.1	·	·	+	·	·	1.1
Morus australis (*Morus bombycis* var. *bombycis*)	T1T2SH	+	·	+	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·
Arisaema amurense for. *serratum*	H	+	·	·	+	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Litsea japonica	T2SH	1.1	1.2	1.1	2.3	·	·	·	·	·	·	·	·	·	+.2	·	·	·	·	·	·	+	·	·	·	+	·	·	·	·	·	·	·	·	·	+
Ilex macropoda	T1SH	1.2	·	1.1	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Dryopteris lacera	H	+.2	+.2	+.2	1.2	·	·	·	·	·	·	·	·	·	+	·	·	·	+	·	·	·	·	·	·	+.2	·	·	+	+	·	·	·	·	·	·
Viburnum odoratissimum var. *awabuki*	H	·	+.2	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Viburnum dilatatum	SH	+.2	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·
Ligularia fischeri	H	+.2	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Galium kinuta	H	+.2	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Sanicula chinensis	H	1.2	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Aphananthe aspera	T1T2SH	·	·	·	·	1.1	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+
Actinidia arguta (*Actinidia arguta* var. *arguta*)	T1T2SH	·	·	·	·	·	+.2	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·

Differential species of *C. sieboldii* forest																																				
Castanopsis sieboldii	T1T2SH	·	·	·	·	1.1	1.1	·	1.1	1.2	4.4	4.4	5.4	4.4	4.4	4.3	4.4	4.3	4.3	4.4	4.4	5.5	4.4	4.4	4.4	4.4	2.2	3.3	2.2	1.2	1.2	3.2	2.2	1.1	·	1.1
Machilus japonica	T1T2SH	·	1.1	+.2	+	2.2	+.2	2.2	2.2	1.2	1.1	1.2	·	·	1.2	1.1	+	2.2	1.2	2.2	1.2	·	·	·	·	·	·	·	·	·	·	·	·	·	·	1.2
Kadsura japonica	SH	1.2	+.2	1.2	+	1.2	+.2	1.1	2.2	+.2	·	·	·	·	1.2	1.2	+.2	+.2	1.1	1.2	1.2	·	·	·	·	+	·	·	·	·	+	·	·	·	·	1.1
Arisaema ringens	H	+	+	+	+	+	·	·	+	+	·	+	+	+	+	·	·	·	+	·	+	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·
Arachniodes aristata	H	·	·	·	·	·	·	·	+.2	·	·	+	+	+	·	·	·	2.1	+.2	+.2	+.2	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+
Dryopteris caudipinna	H	·	·	·	·	·	·	·	·	·	·	·	+	·	·	+	+.2	+.2	·	·	·	·	+	·	·	·	·	+.2	·	·	·	·	·	·	·	·
Dryopteris nipponensis	H	·	·	+	+	·	+	·	·	·	·	·	·	·	+.2	+.2	+.2	+	+.2	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·
Carex lenta	H	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	+.2	+	·	·	·	·	·	·	·	+.2	·	·	·	·	·	·
Raphiolepis indica var. *umbellata*	T1SH	·	·	·	·	+	·	·	·	·	·	+	·	·	+.2	+	·	·	·	·	·	+	+.2	+	+.2	+.2	·	·	·	+	·	·	1.2	2.3	1.2	·
Fraxinus sieboldiana	SH	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	1.1	+	·	·	·	·	·	·	·	1.2	2.2	1.2	·
Hemerocallis fulva var. *fulva* (*Hemerocallis fulva*)	H	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+.2	+	·	·	·	+	·	·	·	+.2	+.2	+.2	1.1	·
Hosta longipes var. *longipes* (*Hosta longipes*)	H	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+.2	1.1	·	+.2	·	1.1	·	·	·	·	+.2	+	1.2	·
Pinus densiflora	T1T2	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	1.1	1.1	2.3	1.2	·	1.1	·	·	·	·	·	·	1.1	·
Disporum smilacinum	H	+.2	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	+	+	+	·	+	+	·	·	·	·	·	·	·
Cymbidium goeringii	H	·	·	·	+	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	+	·	+.2	+	·	·	·	·	·	·	+	+	·	·
Dryopteris fuscipes	H	+.2	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	+	·	·	·	·	·	·	·	·	·	·	·	·
Polygonatum involucratum	H	+.2	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	+	·	·	·	·	·	·	·	·	·	·	+	·
Mitchella undulata	H	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	+.2	·	·	·	·	·	·	·	·	·	·	·	·
Differential species of *Q. acuta* forest																																				
Quercus acuta	T1T2SH	·	·	·	·	1.2	1.1	·	·	1.2	·	·	2.2	2.2	·	2.2	2.2	2.3	3.2	·	·	·	1.2	1.2	+	1.2	4.4	4.3	4.4	3.4	4.4	4.3	1.2	·	·	·
Callicarpa japonica	SH	+	+	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	+	+.2	+	+	·	·	·
Damnacanthus indicus	SH	·	·	·	·	·	·	·	·	·	·	·	·	2.2	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	+	·	·	·	·	+
Liriope spicata	H	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	+	·	·	·	·	·
Ailanthus altissima	T1S	·	·	·	·	·	·	1.1	·	·	·	·	·	·	1.1	·	·	·	·	·	·	·	·	·	·	·	·	·	+	1.1	·	·	·	·	·	·
Carex ciliatomarginata	H	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	+	+	·	·	·	·	·	·	+	·
Differential species of *C. turczaninovii* forest (Elements of edaphic climax forest)																																				
Carpinus turczaninovii	T1T2SH	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	1.2	1.1	+	1.1	2.2	·	·	4.3	4.4	4.4	·
Rubus corchorifolius	SH	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	+	+	+	·
Melampyrum roseum var. *japonicum*	H	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+.2	+	1.1	·
Miscanthus sinensis for. *purpurascens* (*Miscanthus sinensis* var. *purpurascens*)	H	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	+	+	·
Oplismenus undulatifolius var. *undulatifolius*	H	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	+	+.2	+.2	·
, etc.	SH	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	+	·
Ostericum praeteritum	H	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	+	·	+.2	·
Cocculus orbiculatus (*Cocculus trilobus*)	SH	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	+	+	·	·
Fraxinus rhynchophylla	SH	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	+	+	·	·

Vitis coignetiae	H	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	+	+	·	·
Lindera obtusiloba	SH	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	+	·	·
Rhus javanica var. *chinensis* (*Rhus javanica*)	SH	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+.2	+	·
Hepatica nobilis var. *japonica* for. *variegata* (*Hepatica asiatica*)	H	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	1.2	·
Chrysanthemum seticuspe for. *boreale* (*Dendranthema boreale*)	H	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+.2	+	·
Quercus serrata	T1T2SH	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	1.1	·	·	·
Rhododendron mucronulatum var. *mucronulatum*	S	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	1.2	·	·
Rhaphiolepis indica var. *integerrima*	T2S	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	2.2	·
Elements of climatic climax forest (evergreen broad-leaved forest)																																				
Ophiopogon japonicus	H	+.2	+	+	+	+	+	·	+	+.2	+	·	·	+	+	+	+	·	+	+	+	+	+	·	+	+	+	+.2	+	+	+	+	+	·	·	+
Dryopteris erythrosora	H	+	+.2	+.2	·	·	+	·	1.1	+.2	+	+	·	+.2	+	·	+.2	·	·	+	1.1	·	+.2	+	+.2	+.2	+.2	+	+.2	+	+.2	+.2	·	·	·	+.2
Aucuba japonica	T2SH	3.2	2.3	2.3	2.2	1.2	2.2	2.2	1.2	+.2	1.2	·	·	+	2.2	1.1	1.2	1.2	1.1	1.1	1.1	·	·	·	1.1	·	·	·	1.1	+	·	·	·	·	·	1.2
Neolitsea aciculata	T1T2SH	·	·	·	·	·	·	1.1	2.2	+	+	1.1	·	1.2	·	1.1	+.2	1.2	1.2	1.2	2.3	·	·	+	1.2	·	+	·	·	·	2.3	·	·	·	·	·
Dryopteris bissetiana	H	·	+	·	·	·	·	·	+	·	·	+	+	+	·	·	·	·	·	+	+	·	+	+.2	·	+	+	·	+	·	+	·	·	+	·	+
Daphniphyllum macropodum	T1T2SH	·	·	·	·	·	1.1	·	·	·	·	·	·	·	·	1.2	+	·	·	·	1.2	+	+.2	+.2	1.2	·	1.2	1.1	1.1	·	·	+.2	·	·	·	1.2
Elaeagnus glabra	T2SH	+.2	·	·	·	1.1	·	·	·	+	+	·	+	·	·	·	+	·	·	·	+	·	·	·	+	+	·	·	+	·	+	·	·	·	·	·
Liriope platyphylla	H	+	·	·	+	·	·	·	·	·	+.2	·	·	·	+	+	·	·	·	·	·	·	·	·	·	+	+	·	·	+	·	·	+	·	·	·
Cinnamomum tenuifolium (*Cinnamomum japonicum*)	T1T2SH	+.2	·	·	+	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	+	·	+	·	·	·	·	+.2	·	·	·	·	·	·
Gardneria insularis	SH	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	+	+	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·
Ficus erecta	T1T2SH	1.1	+	+.2	1.1	·	1.1	2.2	1.2	+	1.1	+.2	+	+	+	+.2	·	+.2	1.1	·	1.2	·	+	·	·	·	·	·	+	·	+	1.2	·	·	·	1.2
Dryopteris hondoensis	H	·	·	+	·	·	+	+.2	+.2	·	·	+	+.2	+.2	+	·	·	+.2	+	+.2	+	·	+	+	+.2	+	+.2	+	+	·	+.2	·	·	·	·	·
Ophiopogon jaburan	H	·	·	·	·	1.2	·	+	·	+.2	1.1	·	+.2	+.2	·	·	+.2	+.2	+.2	·	+	·	·	·	·	·	·	·	+.2	+	+	1.2	·	·	·	+
Dryopteris pacifica	H	·	+	·	·	·	+	·	·	·	·	·	·	+	·	·	·	+	·	·	·	+.2	+.2	·	·	+	·	+	·	·	·	·	·	·	·	·
Litsea coreana (*Actinodaphne lancifolia*)	T1T2SH	·	·	·	·	·	·	·	·	+.2	·	·	+	+	·	·	+	1.1	+	·	·	·	+	·	·	·	·	·	·	·	·	+	·	·	·	·
Cyrtomium falcatum	H	·	·	·	·	·	·	·	1.1	·	·	·	·	·	·	·	·	·	+	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+
Euonymus japonicus	SH	+.2	·	·	·	+	·	·	·	·	·	·	·	·	·	+	+	+	+.2	·	+	·	·	·	+	+	·	·	+	1.1	·	+.2	·	·	·	+
Stauntonia hexaphylla	T1T2SH	+	+	+	+	·	·	+	·	+	+	·	·	·	+	·	+	+	·	·	·	+	+	+	+.2	+	·	+	+	·	+	+	·	·	·	+
Lemmaphyllum microphyllum	H	·	·	·	·	+	·	+	+	·	+	+	+	+	·	·	+	+	+	·	+	+	+	·	·	+	·	+	·	+	+	+	·	·	·	+
Calanthe discolor	H	·	·	·	+.2	·	·	·	·	+	·	·	+.2	+	·	·	+	·	+	·	+	·	·	+	+	+	·	+	·	·	·	·	·	·	·	·
Euscaphis japonica	T1T2SH	1.2	·	·	1.1	1.1	1.1	·	+	·	·	·	·	·	·	+	·	·	·	·	·	+	·	+	·	1.1	+	·	·	·	·	·	·	·	·	+
Pittosporum tobira	SH	·	·	·	·	+	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	+	+	·	·	·	·	·	·	·	·	·	·
Sinomenium acutum	T1T2SH	·	+	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Viola chaerophylloides var. *chaerophylloides* (*Viola albida* var. *chaerophylloides*)	H	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·
Styrax japonica	T1T2SH	1.1	·	·	·	+	·	1.1	·	·	·	·	·	·	1.1	+	·	·	·	·	·	·	·	·	·	+	·	·	+	·	·	·	·	·	·	·

Elements of *Q. acuta* & *C. sieboldii* forests																																				
Viburnum erosum	SH	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+.2	·	+	·	+	·	+.2	·	·	·	·	·	·
Ardisia crenata	SH	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	+	·	·	+	·	+	·	·	·	·	·	+	·	·	·	·	·
Ilex integra	T1T2SH	·	·	·	·	·	·	·	·	·	+	·	+	+	·	·	·	·	·	·	·	·	1.2	·	·	+	+	+	·	·	+	·	·	·	·	·
Ficus nipponica (Ficus oxyphylla)	T2SH	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	+	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·
Vaccinium bracteatum	T1SH	·	·	·	·	·	·	·	·	·	·	·	+	+	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	+	·	·	·
Tylophora floribunda	H	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	+	·	·	·	+	·	·	·	+	·	·	·	·	·	·
Character and differential species of Camellietea japonicae																																				
Camellia japonica	T1T2SH	+.2	2.3	2.3	2.2	3.3	3.3	2.2	2.3	2.2	2.3	3.3	3.3	2.3	3.3	3.3	2.3	3.3	2.3	3.3	2.2	2.3	1.1	+.2	2.2	3.3	+.2	+.2	3.3	3.3	2.2	3.3	2.2	1.2	1.2	4.3
Neolitsea sericea	T1T2SH	2.3	2.3	2.2	+.2	2.2	2.3	2.2	3.2	3.3	1.1	1.2	·	+	1.2	2.2	1.1	2.2	2.2	1.2	1.2	·	+	+	1.2	+.2	+	·	2.2	2.2	1.1	+.2	+	·	·	2.3
Eurya japonica	T1T2SH	1.2	·	·	1.2	·	+.2	·	·	2.2	2.2	·	2.2	1.2	1.2	2.2	1.2	1.1	2.3	·	·	1.2	2.3	3.2	1.2	2.2	+.2	2.2	+.2	·	2.2	+.2	·	+	·	·
Trachelospermum asiaticum (Trachelospermum asiaticum var. *asiaticum)*	T2SH	2.3	2.2	·	2.2	2.2	1.2	2.2	1.2	2.2	2.2	2.2	2.3	3.3	2.2	1.1	2.2	2.3	2.2	1.2	2.2	2.2	2.2	2.2	4.4	3.4	4.3	3.3	3.3	4.4	2.3	3.3	4.4	4.3	4.4	1.2
Dendropanax morbiferus	T1T2SH	+.2	+.2	+	·	1.1	2.2	1.2	1.1	2.2	1.2	+.2	2.2	2.2	2.2	1.2	2.2	1.2	2.2	1.2	2.2	·	2.2	2.2	1.2	+.2	2.2	2.3	1.2	+	2.2	2.2	·	·	·	+.2
Ardisia japonica	H	1.2	+.2	1.1	1.2	+.2	+	·	1.1	+.2	+.2	·	1.2	·	+.2	+.2	+.2	·	+.2	+.2	1.2	+	1.2	1.2	1.1	2.2	1.1	1.2	+.2	·	1.2	+.2	·	+.2	+.2	·
Ligustrum japonicum (Ligustrum japonicum var. *japonicum)*	T1T2SH	+.2	+	·	+.2	+.2	+.2	+	·	+	2.2	·	1.2	·	+.2	+.2	+.2	1.1	1.1	·	1.2	1.1	2.2	1.2	+.2	1.2	1.2	1.1	+	+	1.2	1.1	1.1	1.2	+	·
Companions																																				
Smilax china	T1T2SH	+	+	·	+	+	+	·	+	·	+	1.2	+	·	·	+	·	·	·	+	+	+	+.2	+	+.2	+.2	+	+	·	+	+	+	+	·	+.2	1.1
Mallotus japonicus	T1T2SH	1.2	2.2	2.2	1.1	1.2	+	1.1	2.2	·	·	1.1	·	·	·	1.1	·	1.1	1.1	·	·	·	·	·	·	+	·	·	1.1	1.1	·	1.2	+	+.2	+	1.1
Elaeagnus macrophylla	SH	·	·	·	+	+	·	+	·	·	+	+	·	·	+	·	+	+	+	·	+	+	·	·	+	+	·	·	+	+	+	+	+	·	+	·
Callicarpa japonica var. *luxurians*	SH	1.1	·	·	+	+	·	·	·	·	·	·	+.2	·	+	·	·	·	·	·	·	·	+	+	+	+.2	+	·	+	+	+.2	+	+	·	+.2	·
Paederia scandens (Paederia scandens var. *scandens)*	SH	·	·	·	+	+	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	+.2	+	+	·	+.2	·	·	·	+.2	·	·	+	+	+	·
Farfugium japonicum	H	·	·	·	+.2	·	·	·	·	·	·	·	+	·	+	·	·	·	·	·	·	+	+	·	·	+.2	·	+	+	·	·	+	+	·	+	·
Euonymus oxyphyllus	SH	+.2	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	+	+.2	·	+.2	·	+	·	·	·	+	+	+	·	·
Pueraria lobata	T1T2SH	·	·	+	+	·	·	·	·	·	·	·	·	·	·	+	·	·	·	+	·	+	·	·	·	+	·	·	·	·	·	·	+	+	·	+
Lepisorus onoei	H	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	+	·	+	·	·	+	·	+	·
Cerasus sargentii (Prunus sargentii)	T1T2SH	·	·	·	1.1	·	+	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	+	·	·	·	·	·	1.1	·	·	·	·	·	·
Acer pictum subsp. mono	T1T2S	1.1	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	1.1	·	·	·	·	1.1	1.1
Phaenosperma globosum (Phaenosperma globosa)	H	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	+	·	·	·	+	·	·
Thalictrum actaeifolium (Thalictrum actaefolium var. *brevistylum)*	H	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	+	·	·	·	·	·	·
Aster scaber	H	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	+	·	·	·	·	·	·	·	·	·
Rhus succedanea	T1T2SH	·	·	·	·	·	·	·	·	·	·	·	·	1.2	·	·	·	·	·	·	·	·	·	·	·	·	·	·	1.1	·	·	·	·	·	·	1.1
Carex humilis var. nana	H	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+.2	·	·	·	·	·	·	·	·	·	+.2	·	·
Selaginella tamariscina	H	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	+	·
Ligustrum obtusifolium	SH	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+.2	·	·	+	·	·	·
Phryma leptostachya subsp. *asiatica*	H	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·

Trichosanthes kirilowii var. *japonica*	SH	·	·	·	·	·	·	+.2	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·
Acer pseudosieboldianum	T2SH	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+.2	·	·	1.2	·	·	·	·	·	·	·	·	·
Davallia mariesii	H	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	+	·	·	·
Lophatherum gracile	H	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+.2	·	·	·	·	·	+	·	·	·
Cayratia japonica	SH	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Cyrtomium fortunei var. *clivicola*	H	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	+.2	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Neoshirakia japonica (Sapium japonicum)	T2SH	·	·	·	·	·	·	·	·	·	1.1	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+
Aria alnifolia (Sorbus alnifolia)	T1T2SH	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	1.2	·	·	·
Ficus erecta Thunb. for. *sieboldii (Ficus erecta* var. *sieboldii)*	S	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+
Stephanandra incisa (Stephanandra incisa var. *incisa)*	SH	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·
Lepisorus thunbergianus	H	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·
Wisteria floribunda (Wisteria floribunda for. *floribunda)*	T2H	·	·	·	·	·	·	·	·	·	·	2.2	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·

*Releve number (1): the number of present research stands (2010); Releve number (2): the number of other's research stands (Kim, 1986)

** units and subunits: Ⅰ (*H. rhombea-M. thunbergii* community), Ⅱ-1 (*M. japonica-C. sieboldii* community), Ⅱ-2 (*R. indica* var. *umbellata-C. sieboldii* community), Ⅲ (*Q. acuta* community), Ⅳ (*C. turczaninovii* community), Ⅴ (*C. japonica* stand), a (*D. lacera-L. japonica* group), b (*A. aspera* group), c (Typical group), d (Typical group), e (*D. nipponensis-K. japonica* group), f (*C. lenta* group (1)), g (*C. lenta* group (2)), h (*P. densiflora* group)

The releve numbers are matched with the one of lines on Fig. 4.

Species (+ and one time) of companions: HD01 (*Cornus walteri*), HD04 (*Pourthiaea villosa* var. *villosa, Dioscorea quinqueloba, Rhamnus koraiensis, Cerasus leveilleana* (Prunus verecunda var. *verecunda*), *Viola grypoceras, Commelina communis, Polygonatum odoratum* var. *pluriflorum*), HD05 (*Aralia elata, Lespedeza maximowiczii, Rhododendron mucronulatum* var. *ciliatum, Saussurea pulchella, Pteridium aquilinum* var. *latiusculum, Peucedanum terebinthaceum, Eupatorium makinoi* var. *oppositifolium, Melica onoei*), HD06 (*Viola rossii, Polystichum ovatopaleaceum* var. *coraiense*), HD08 (*Asparagus schoberioides*), HD09 (*Clematis terniflora* var. *mandshurica*), HD10 (*Euonymus alatus* f. *striatus* (*Euonymus alatus* f. *ciliatodentatus*)), HD15 (*Picrasma quassioides, Pseudostellaria heterophylla*), HD16 (*Galium trifidum* subsp. *columbianum* (*Galium trifidum*), *Allium macrostemon*, *Hypochaeris radicata, Crepidiastrum denticulatum*), HD21 (*Zanthoxylum ailanthoides* var. *ailanthoides* (*Zanthoxylum ailanthoides*), *Codonopsis lanceolata, Goodyera schlechtendaliana, Disporum viridescens, Bulbophyllum inconspicuum*), HD22 (*Atractylodes ovata*), HD30 (*Cleyera japonica*), HD34 (*Asarum sieboldii*)

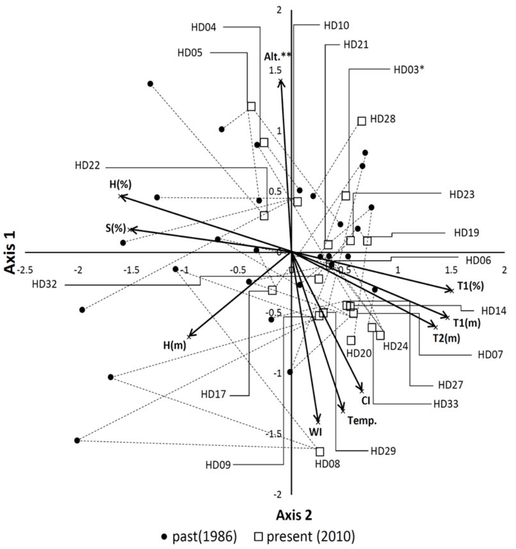

Fig. 4. Diagram of CCA about correlation among the vegetation transition, forest structure and climate factors
Present (2010): releve number (1) of Table 1; Past (1986): releve number (2) of Table 1
* The releve number (1) of Table 1
** Alt.: Altitude; Temp.: Annual mean temperature; T1 (m)-H (m): The heights (refer to Table 1); T1 (%)-H (%): the coverages (refer to Table 1).
Environmental factors: annual mean temperature, warmth index, coldness index, precipitation
The dotted line means the direction of vegetation transition from the past to the present.

the vegetation coverage on tree, shrub and herb layers and the vegetation height on tree and subtree layers, and from the 112 stand according to the change of vegetation height on a herb layer. In cases of the 63 and 113 stands, the vegetation structures are confirmed to change remarkably from the past to the present stands as from the no tree layer to the average vegetation height and coverage of 12m and 92.5%, from the average height about 4m to 9m on the subtree layer, from the average coverage 40-90% to 35-40% on the shrub layer and from the average coverage 20-50% to 20-40% on the herb layer. In case of the vegetation, the *M. thunbergii* community in the past study (112, 113 stands) and the *D. macropodum* subcommunity in *Aucuba japonica* community (13 stand) are changed to the *H. rhombea-M. thunbergii* community according to the quantitative change of *C. japonica*, *Ardisia japonica*, *S. chinensis*, *N. sericea*, *L. japonicum*, etc..

The vegetation of HD08 and HD09 stands of *D. lacera-L. japonica* group in the *H. rhombea-M. thunbergii* community is changed from the past study stands of no. 65, 114 and 115 according to the changes of the vegetation height and coverage on a tree layer, the vegetation height on a subtree layer and the vegetation coverage on shrub and herb layers (65, 114, 115 stands), the vegetation coverage on a herb layer (65, 115 stands) and the climatic conditions (114 stand). HD08 stand especially is correlated to the change of the vegetation height and coverage, and HD09 stand is correlated to the change of the vegetation height on the herb layer.

The vegetation transition of HD24 stand in the typical group of the *H. rhombea-M. thunbergii* community from the past stands (*M. japonica* subcommunity in *Aucuba japonica* community: 29, 30, 31) is correlated to the change of climate conditions considerably, and to the change of the vegetation height on the tree, subtree layers and the vegetation coverage on the tree, shrub and herb layers slightly. At the change of climate conditions in the HD stand, WI increases about 1.39℃ from 104.18℃ to 105.57℃, and CI and mean annual temperature also increases about 2.31℃ from -9.49℃ to -7.80℃ and about 0.33℃ from 12.5 7℃ to 12.90℃. The temperature conditions therefore influence most significantly among the climate conditions.

The vegetation transition of HD33 stand in the typical group of the *H. rhombea-M. thunbergii* community from the past stands (*Q. acuta* community in the past study: 101) is not correlated to the change of vegetation height, coverage and the climate conditions. *Q. acuta*, *C. sieboldii*, *D. morbiferus*, etc. dominating on the tree layer in the past study have existed, but the dominance value of the species decrease in the present study except for *D. morbiferus*. The most of species appearing in the past study exist in the present study, and *M. thunbergii*, *N. sericea*, *M. japonica*, *Aucuba japonica*, *K. japonica*, *O. jaburan*, *Ardisia japonica*, *D. erythrosora*, etc. appear newly. It therefore shows that *Q. acuta* forest in the past study alters to *M. thunbergii* forest in the present study. That means it is possible that there are the external influences or the introduction of species for the formation of new vegetation, or the problem about the selection of representative study plots in a forest. The present stand is the one of *C. sieboldii* forest according to the vegetation result in this study and the data of Environmental Geograpic information System (EGIS, 2010).

3.2.2.2. *C. sieboldii* forest

The vegetation transition of HD19 and HD32 stands in the *M. japonica-C. sieboldii* community from the past stand (*Aucuba japonica* community: 35 stand) is correlated considerably to the changes of climate conditions (HD19) and vegetation height on the herb layer (HD32). The EBLS as *M. japonica*, *L. japonicum*, *Aucuba japonica*, *L. microphyllum* etc. appear the both of past and present studies, and the dominance of the EBLS decreases or maintains as it is. The typical EBLS as *C. sieboldii*, *C. japonica*, *Q. acuta*, *E. japonica*, *N. aciculata*, *L. coreana*, *N. sericea*, *D. morbiferus*, *M. thunbergii*, *T. asiaticum*, *A. aristata*, etc. in the warm-temperate zone appear newly.

The vegetation transition of HD03 stand in the *D. nipponensis-K. japonica* group of *M. japonica-C. sieboldii* community from the past stand (*Aucuba japonica* community: 105 stand) is correlated to the change of vegetation on the herb layer compared to the other conditions. The community in the past study is more slimilar to *C. sieboldii* forest such as this present stand according to the dominances of the component species of canopy vegetation although the *Aucuba japonica* community was named in the past study. The vegetation height and coverage from tree to herb layers increase except for the coverage on the herb layer. *C. sieboldii*, *C. japonica*, *M. thunbergii*, *M. japonica*, *D. morbiferus*, etc. on the tree layer have dominated in the past and the present studies, and the dominance of the species increases or maintains as it is.

The vegetation transitions of HD20 stand in the *M. japonica-C. sieboldii* community and HD21 in the *R. indica* var. *umbellata-C. sieboldii* community from the past stand (34 stand) are correlated relatively considerably to the vegetation height on the herb layer. The vegetation height on the each layer increases except for the DH21 stand without the subtree layer, and the vegetation coverage on the tree and subtree layers tends to decrease and that on the shrub and herb layers tends to increase. A *T. asiaticum-Q. acuta* community dominated by *Q. acuta* in the past study is changed to the one unit of *C. sieboldii* forest dominated by *C. sieboldii*. *Q. acuta* dominating at the dominance・sociability of '5.5' in the past study decreases adequately to those of '3.2 and 1.2'. the low dominance (+) of *C. sieboldii* on the shrub layer increase to the adequately high dominances・sociabilities of '4.3-4.4' in the present study.

It is the cause and result of this vegetation transition that the expansion of *C. sieboldii* forest and the diminution of *Q. acuta* forest (a vertical migration of vegetation zone) according to the temperate to rise by global warming, and the external influences or the introduction of species for the formation of new vegetation. The dominance of *C. japonica*, *E. japonica*, *N. aciculata*, *T. asiaticum*, *Aucuba japonica*, *O. jaburan*, *L. microphyllum*, etc. maintains as it is in the both of past and present studies. New component species by the possibility of introduction from without are the EBLS as *N. sericea*, *D. morbiferus*, *M. thunbergii*, *K. japonica*, *Ardisia japonica*, *D. nipponensis*, *A. aristata*, etc. and the DBLS as *M. japonicus*, *F. erecta*, etc..

The vegetation transition of HD10 stand in the *P. densiflora* group of *R. indica* var. *umbellata-C. sieboldii* community from the past stand (*R. indica* var. *umbellata-C. japonica* community: 61, 110, 111 stands) is correlated relatively considerably to the change of vegetation height on the herb layer. The tree layer did not exist in the past stand, but the vegetation with the tree layer of 9m height is formed. The vegetation height on the shrub layer increases, but that on the herb layer decreases. In case of the vegetation coverage, the coverage on the shrub layer decreases sharply, and that on the herb layer decreases about 10-20%. It affects the change of vegetation coverage on the shrub layer that the development of *C. japonica* and *N. aciculata*, the decrease of dominance of *E. japonica*, *N. sericea*, *S. china*, *M. thunbergii*, etc. on the same layers, *M. japonicus*, *C. turczaninovii*, *Euscaphis japonica*, *Ligustrum obtusifolium* and *Callicarpa japonica* which do not exist in the present stand, and *C. sieboldii*, *C. japonicum*, *P. densiflora*, *D. morbiferus*, *S. hexaphylla*, etc. appearing newly in the present stand. the introduction of *C. sieboldii* also influences the change from *R. indica* var. *umbellata-C. japonica* community in the past study to the present community. *R. indica var. umbellata* remains as the differential species for the classification of community.

3.2.2.3. *Q. acuta* forest

The vegetation transition of HD22 stand in the *Q. acuta* community from the past stand (*Q. serrata* community: 40 stand) is correlated relatively to the change of climate conditions (CI, mean annual temperature). The tree and subtree layers appear newly, and the vegetation height on the shrub and herb layers increases and the coverage on those layers decreases.

Q. serrata community in the past study is changed to *Q. acuta* forest in the present study. *Stephanandra incisa*, *V. erosum*, *F. rhynchophylla*, *Lespedeza maximowiczii*, *E. oxyphyllus*, *R. mucronulatum* var. *mucronulatum*, *Carex humilis* var. *nana*, etc. as the DBLS in the warm-temperate zone or the species that can be distributed in a temperate zone do not exist in the present study. the DBLF is therefore changed to the EBLF according to the temperature to rise or the newly external introduction of EBLS on the tree layer as *Q. acuta*, *C. sieboldii*, *D. macropodum*, *D. morbiferus* and *M. thunbergii*.

The vegetation transition of HD28 stand in the *Q. acuta* community (*Ardisia japonica-C. sieboldii* community: 46 stand) is correlated relatively to the change of vegetation height on the herb layer. The vegetation height on the most of layers increases except for the tree layer appearing newly in the present stand and the vegetation coverage on the all of layers decrease. *Ardisia japonica-C. sieboldii* community is changed to *Q. acuta* community. *C. sieboldii* dominating on the canopy has maintained without the change of dominance.

The vegetation transition of HD23 stand in the *Q. acuta* community from the past stand (*T. asiaticum-Q. acuta* community: 28 stand) is correlated to the change of vegetation height on the herb layer. The *T. asiaticum-Q. acuta* community has changed to the *Q. acuta* community. The development of vegetation height and the increase of the dominances・sociabilities of *Q. acuta*, *N. aciculata*, *C. sieboldii*, etc. increases, although there is few component species. The vegetation height and coverage on the all of layers increase except for the coverage on the tree layer. The vegetation coverage on the subtree and shrub layers especially decreases considerably.

Q. acuta forest as the incomplete climax forest in the past study is therefore changed to the *Q. acuta* forest with the vegetation structure and species composition of climax forest in the present study. *N. sericea*, *C. japonica* var. *luxurians*, *Ardisia japonica*, *D. hondoensis*, *D. erythrosora*, etc. appear newly, and *Euscaphis japonica*, *Aucuba japonica*, *H. rhombea*, *O. undulatifolius* var. *undulatifolius*, *A. ringens*, etc. do not exist no longer in the present study.

The vegetation transition of HD17 in the *Q. acuta* community from the past stand (*T. asiaticum-Q. acuta* community: 47, 103 stands) is correlated relatively to the changes of climate conditions (47 stand) and the vegetation height on the herb layer (103 stand). the growth of vegetation height increases on the all of layers, and The vegetation coverage on the most of layers increases or maintains as it is except for the decrease of vegetation coverage on the subtree layer. The change of dominance・sociability of *Q. acuta* is various to increase or decrease, but those of *C. japonica*, *C. sieboldii*, *T. asiaticum*, *D. morbiferus*, *O. jaburan*, etc. increase. *N. sericea*, *L. coreana*, *E. japonicus*, *H. fulva* var. *fulva*, *A. ringens*, etc. appear newly. Although there is therefore no an entire vegetation transition, the vegetation complexifies according to the introduction of various species and the change of dominances of the species.

3.2.2.4. *C. turczaninovii* forest

The vegetation transition of HD04 in the *C. turczaninovii* community from the past stand (*C. turczaninovii* community: 48 stand) is correlated to the change of climate conditions (CI, mean annual temperature). The canopy vegetation with the vegetation height and coverage of 5m and 85% form without the subtree layer in the present study, although tree layer did not exist and subtree layer existed in the past study. The vegetation height on the shrub and herb layers is few changed. The vegetation coverage on the herb layer is changed considerably, but that of shrub layer is not changed. The *C. turczaninovii* community dominated by *C. turczaninovii* on the subtree layer in the past study is changed to the *C. turczaninovii* community dominated by *C. turczaninovii* on the tree layer in the present study. The dominant species as *Q. acuta* and *C. turczaninovii* on the subtree layer and *C. japonica* and *L. japonicum* on the shrub layer in the past stand is changed and grow and then dominate. *C. sieboldii*, *Q. serrata*, etc. tend to be brought newly into from without on the tree layer. *R. indica var. umbellata* on the shrub layer and *T. asiaticum* on the herb layer in past stand are not changed. The component species of *C. turczaninovii* community on the barren conditions which have relatively edaphic influences as *F. sieboldiana*, *H. longipes* var. *longipes*, *M. roseum* var. *japonicum*, *H. fulva* var. *fulva*, etc. appear newly. If the maintenances of vegetation transition and temperature to rise continue, this stand will be succession toward C. sieboldii forest in Hong-Do island according to the component species as *R. indica var. umbellata*, *F. sieboldiana*, *H. fulva* var. *fulva*, *H. longipes* var. *longipes*, etc.

The vegetation transition of HD05 in the *C. turczaninovii* community from the past stands (49, 51, 106 stands) is correlated relatively to the changes of the WI (49 stand), the CI and annual temperature (51 stand) and the vegetation height on the herb layer (106 stand). The *R. indica* var. *umbellata-C. japonica* community (49 stand), the *Aucuba japonica* community (51 stand) and the *Q. serrata* community (106 stand) in the past stands are changed to the *C. turczaninovii* community. In the *Q. serrata* community, *C. turczaninovii* appears with the high dominance in the present study and the low dominance of *T. asiaticum* on the herb layer in the past stand is changed to the high dominances on the same layer in the present stand. In the *Aucuba japonica* community, *C. japonica*, *M. thunbergii*, *D. macropodum*, *M. japonica* dominating on the canopy in the past stand do not exist or exist with the low dominances in the present stand, and *C. turczaninovii*, *T. asiaticum*, *F. sieboldiana*, etc. appear newly or have the increased dominances.

3.2.2.5. *C. japonica* stand

The vegetation transition of HD27 in the *C. japonica* stand from the past stand (45 stand) is scarcely correlated to the changes of vegetation structures and climate conditions. The tree and subtree layers form newly. The vegetation height on the shrub and herb layers increases slightly, but the vegetation coverage on the shrub layer decreases considerably. Among *C. japonica*, *C. sieboldii* and *M. japonicus* dominating on the shrub layer in the past stand, the high dominance of *C. japonica* has been maintained, but *C. sieboldii* and *M. japonicus* decrease considerably. The EBLS as *N. sericea*, *F. erecta*, *S. china*, *Aucuba japonica*, *K. japonica*, etc. in the warm-temperate zone appear newly. This results mean that the vegetation transition occurs from the *C. sieboldii* forest to the *C. japonica* stand according to the climax species and the vegetation structure will be maintained if there is no artificial influences.

5. Conclusions

The establishing phytosociological study about the EBLF in Hong-Do island was classified into communities and associations according to the vegetation system of Japan (CHOLLANAM-DO, 1995), but the result of that study tends to be standardized to the vegetation system of Japan for naming association units. In case of the character species of associations in the vegetation system of Japan, some species, which is also the character species of associations in the Japanese vegetation system, appear with similar frequencies, dominances and sociabilities among different communities in this study site. It is more adequate that the species are selected as the character and differential species in the Camellietea japonicae class according to the consideration of the signification and role of character species.

Hong-Do island is seen as located at the midmost geographical position in Northeast Asia, although the island is located near South Korea. There is the vegetation influences of Japan and China as well as that of South Korea toward this island according to the condition of life migration based on the Theory of Island Biogeography. On the vegetation transition due to the temperature to rise by global warming and the typical EBLS or EBLF of Japan and China will be seen as flowed in the island. the continuous monitoring study about Hong-Do island therefore is necessary.

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