韓國環境復元技術學會誌 24(6) : 15～34(2021)
J. Korean Env. Res. Tech. 24(6) : 15～34(2021)
DOI : https://doi.org/10.13087/kosert.2021.24.6.15
ISSN 1229-3032

대청댐 유역 굴참나무림의 군락분류학 및 군락생태학적 연구*

김성열[1] · 문건수[2] · 송원경[3] · 최재용[4]

[1] 엔필드(주) 선임연구위원 · [2] 충남대학교 농업생명과학대학 산림환경자원학과 대학원 학생 ·
[3] 단국대학교 녹지조경학과 교수 · [4] 충남대학교 농업생명과학대학 산림환경자원학과 교수

Syntaxonomy and Synecology of *Quercus variabilis* Forest in Daecheong-dam basin*

Kim, Sung-Yeol[1] · Moon, Geon-Soo[2] · Song, Won-Kyong[3] and Choi, Jaeyong[4]

[1] Enfield Co., Senior Researcher Fellow,
[2] Department of Environment & Forest Resources, Chungnam National University, Student,
[3] Department of Landscape Architecture, Dankook University, Professor,
[4] Department of Environment & Forest Resources, Chungnam National University, Professor.

ABSTRACT

Syntaxonomy and Synecology on *Quercus variabilis* forests in Daecheong-dam basin was carried out using the methods of Braun-Blanquet phytosociology. 6 syntaxa classified as species compositions described were *Quercus variabilis* community, *Platycarya strobilacea-Quercus variabilis* community(typicum subcommunity, *dictamnus dasycarpus* subcommunity), Quercetum variabili-serratae, *Zelkova serrata-Quercus variabilis* community and *Dendranthema boreale-Quercus variabilis* community. All syntaxa were shown habitat environmental conditions including steep inclination of more than 30°, high rock exposure rate of more than 50% and South-facing slope. These communities excepting *Dendranthema boreale-Quercus variabilis* community classified as natural vegetation were identified as low emergence rate of annual plants and

* This study was carried out with the support of ´R&D Program for Forest Science Technology (Project No. "2020201B10-2122-BA01)´ provided by Korea Forest Service(Korea Forestry Promotion Institute).
First author : Kim, Sung-Yeol, Enfield Co, Senior Research Fellow,
Tel : +82-42-821-7835, E-mail : sdzzangksr@naver.com
Corresponding author : Choi, Jaeyong, Department of Environment & Forest Resources, Chungnam National University, Professor,
Tel : +82-42-821-5750, E-mail : jaychoi@cnu.ac.kr
Received : 5 October, 2021. **Revised** : 23 December, 2021. **Accepted** : 23 December, 2021.

species compositions composed native species, so it was confirmed that relatively natural succession were proceeding well. Quercetum variabili-serratae and *Dendranthema boreale-Quercus variabilis* community distributed forested hillslope of open water edge were representative *Quercus variabilis* syntaxa in Daecheong-dam basin.

Key Words : *Secondary forest, Natural succession, Flora, Phytosociology, Steep inclination habitat*

I. Introduction

Generally, hydrologic and water quality in the region of dam changes by the kind of trees, stand age, density, etc. of the forest watersheds distributed nearby (Kim and Jeong, 2006). Therefore, keeping up an intact role and function of the dam's water quality and hydrologic requires the basic information and monitoring work on the forest distributed in the dam basin.

Quercus variabilis, an intolerant tree with big sprouting ability, is seen in every mountain zone of the Korean Peninsula(Kim and Kim, 2017). It is a deciduous, broad leaf tree characterized by barks developing thick cork and by dense growth of light gray asteroid hair on the underside of the leaf (KNA, 2021). In its habitats where *Quercus variabilis* is developing as forest, the trees exhibit drier environmental condition and smaller content of soil organic matters, compared to other oaks, demonstrating the condition of growing well in a barren and dry region, too (Lee et al., 2002; Kim et al., 2010; Kim and Yang, 2017). Syngeographically, *Quercus variabilis* syntaxa in Korea appears from cool-temperate central·montane zone to cool-temperate southern·submontane zone. Horizontally centering distributively on Callicarpo-Quercenion serratae in cool-temperate southern·submontane zone (Kim, 1992), it is vertically forming forest in the lower part of *Quercus mongolica* communities (Kim, 1992; Kim and Kim, 2017). According to the syntaxonomical study of *Quercus variabilis* vegetation, cool-temperate central·montane zone is represented by secondary vegetation type, in which *Quercus variabilis* grows dominantly in the habitat where *Quercus mongolica* climax forest has been damaged by natural disturbance. Syntaxonomical study of *Quercus variabilis* vegetation in Korean peninsula were described diverse plant communities, including *Quercus mongolica-Quercus variabilis* community (Lee et al., 2002; Kim et al., 2003), *Pinus densiflora* community *quercus variabilis* subcommunity (Yun et al., 2010), *Quercus variabilis* community (Kim and Kim, 2008; Kim et al., 2011; Byeon and Yun, 2017), *Pinus densiflora* for. *erecta* community *quercus variabilis* subcommuity (Kim and Yun, 2009) etc. In southern·submontane zone with *Quercus variabilis* forest distributively centering appear secondary vegetation type(Quercetum variabilis Kim et Yim 1986, *Quercus variabilis* community, *Platycarya strobilacea-Quercus variabilis* community, *Lespedeza maximowiczii-Quercus variabilis* community, Quercetum variabili-serratae Kobayashi, Muranaga et Takeda 1976, Commelino-rob-

inietum pseudoacaciae quercetosum variabilis (Kim, 1992; Song and Kim, 1993; Yun et al., 1999; Yun et al., 2001; Kim et al., 2002; Lee and Yun, 2002; Cho and Kim, 2005; Lee and Kim, 2017; Oh et al., 2018), pseudoclimax persistent plant community developing on steep-inclination montane zone slope(*Quercus variabilis* community)(Ji et al., 2003; Bae et al., 2005; Lee et al., 2006; Hwang and Yun, 2007; Lee and Park, 2008), and edaphic climax forest where riparian cliff and scree are developing (*Spiraea chinensis-Quercus variabilis* community) (Lee and Kim, 2017). Besides, for secondary vegetation type developing in warm-temperate zone, we can check *Quercus variabilis* community (Kim et al., 2005), *Pinus thunbergi* community *quercus variabilis* subcommunity (Kim et al., 2000), *Quercus variabilis-Quercus serrata* community (Lee et al., 2011), *Tilia mandshurica-Quercus variabilis* community (Choi, 2014) found in limestone area exhibiting the environmental condition of less moisture by the specificity of bare rock with no steep inclination, and *Quercus variabilis* community (Shin et al., 2017) developing in sedimentary rock area.

This syntaxonomical study of *Quercus variabilis* in Daecheong dam forest basin aims to describe the classification and diversity of plant community on *Quercus variabilis* forest distributed on the Daecheong dam basin and identify the characteristics of Synecology. The syntaxa datas on *Quercus variabilis* forest obtained through this study could be used as basic data to find particularities of *Quercus variabilis* forest in the dam basin distributed in the whole area of the Korean Peninsula and complete the syntaxonomical hierarchy system of *Quercus variabilis* forest in the Korean Peninsula.

II. Method of the study

1. Subject area of the study

Daecheong dam located at Sangdang - gu, Chungju city, is a multipurpose dam built on the upper tributary of the main Geum River. Since the Daecheong dam was designated in November 1980 as water conservation zone and has been in service to supply drinking and irrigating water for Choongcheong-do people, management of its hydrologic and water quality is very important. The study area, located at 36° 09' 39" to 36° 33' 23" N and 127° 24' 08" to 127° 43' 49" E (Figure 1), is 78,789 ha with the boundary of Daecheong dam and its upstream basin. The study area is mostly leaned from 0 to 10° (about 30%) with many regions showing a relatively gentle slope and the mountain area slope mainly directing toward the north (about 19%) (Figure 2). To obtain more accurate climatic information, data for 20 years (2000 to 2019) was used by receiving it from Secheon (AWS no. 643; 36.34019 N, 127.49378 E; 91m *a.s.l*) Automatic Weather System (AWS) (KMA, 2021) installed in the study area area. Secheon [643] annual mean temperature is 12.19 °C, mean annual precipitation 1.220 mm (Figure 3) and average temperature and precipitation for the winter (Dec. through Feb.) - 0.84 °C, 78.4 mm and those for the summer (June through Aug.) 24.65 °C and 709.8 mm, respectively. From these results, the study area demonstrates the climate condition with approximately 58% of annual rainfall focusing on

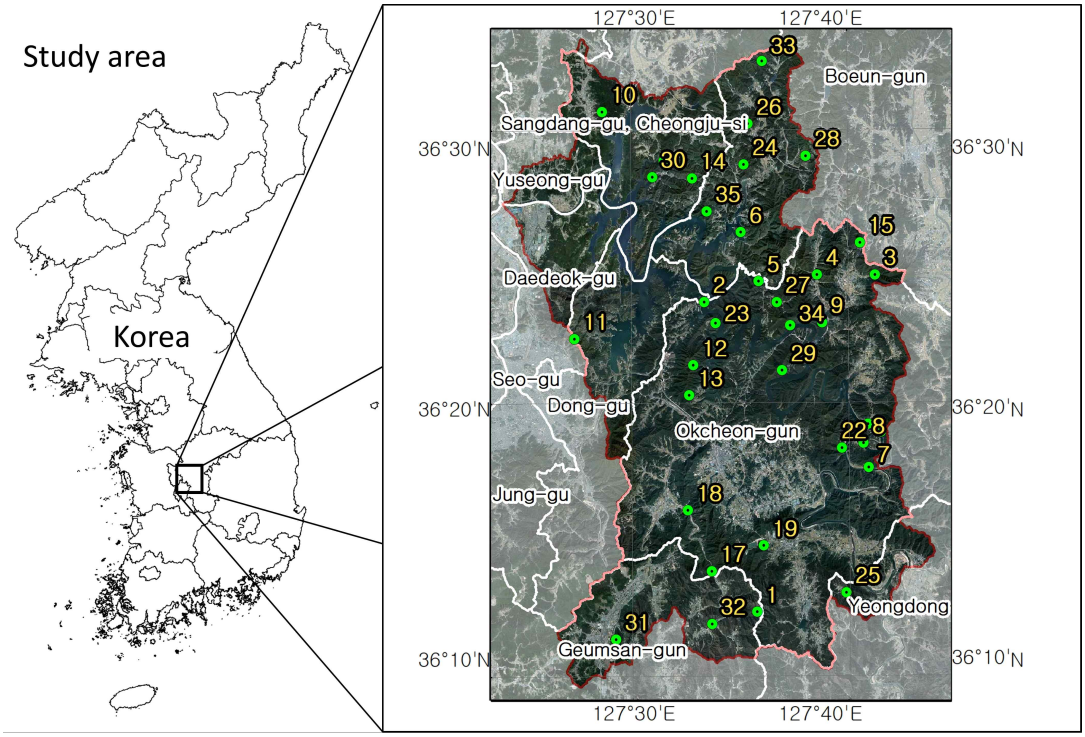

Figure 1. Study boundary and survey points.

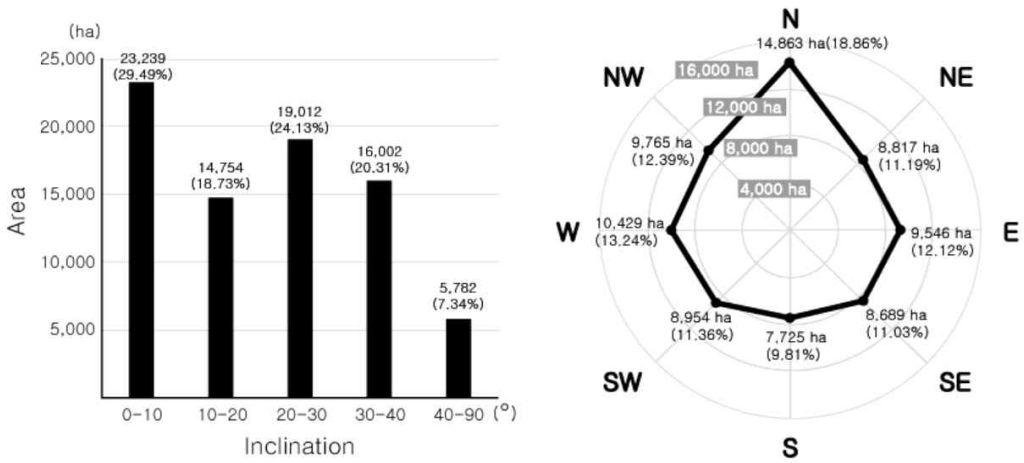

Figure 2. Inclination and aspect in study area.

the summer. The present study site corresponds to Korea's inland bioclimatic region-central and southern inland type, located in Choongcheong-do and the Sobaek mountains, and it is the region typically exhibiting continental climate (Kim and Lee, 2006). Syngeographically, in the study area, Lindero-Quercenion mongolicae of cool-temperate central·montane zone (Kim, 1992) is vertically and horizontally mixed with deciduous broad-leaf forest of Callicarpo-Quercenion serratae for

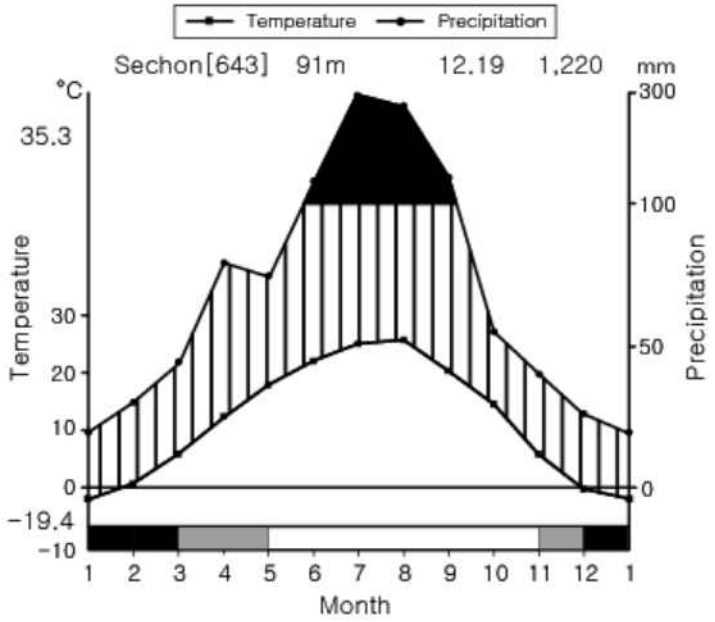

Figure 3. Climate diagram of Sechon [643] AWS in study area.

cool-temperate southern submontane zone.

Bare rocks for study area are Daehyangsan quartzite Formation, Bokpyong Formation, Lower Bibong Formation, Whacheonri Formation, Upper Bibong Formation, Hwanggangri Formation, age-unknown Amphibolite and Jurassic plutonic rocks, This means rocks in metaphoric rock series creating fine-grained soil are mostly distributed as bare rock here (Yoo, 1993).

2. Site survey and analysis method

To obtain data for surveying the vegetation of *Quercus variabilis* forest developing in the study area, forest type map was secured and the 3-5 age-class stand of dominant *Quercus variabilis* on the forest forest map was selected for the primary on-the-spot survey site (NSDIP, 2021). The final survey site was selected via field survey on the homogeneity of habitat environment and *Quercus variabilis* forest with plant species composition representing the study area. Field survey was conducted from June through October, 2020, in consideration of vegetative season with the most species of the year (Kim, 2006). The site vegetative survey was conducted (Kim and Lee, 2006) following the traditional method of Z-M school (Braun-Blanquet, 1964) and relevé was prepared based on floristic-sociological species composition on each habitat. Coverage scale of relevé was found using combined cover degree in 9 classes (Westhoff and Van der Maarel, 1973). The area of the site survey was decided on over squared canopy layer height that can reflect the characteristics of plant species composition, together with habitat characteristics of each vegetative survey area (Kim et al., 1995). All the environmental conditions of habitat, including inclination, sea level, latitude-longitude, microtopography, disturbance location distance, location accessibility and surrounding plant communities, were recorded on the relevé

according to vegetation survey guidelines of the 4th national survey for natural environment (Kim et al. 2012).

Through the field survey, a total of 35 relevé was obtained, which was then analyzed by integrative classification (Kim and Lee, 2006) in consideration of both Z.M school's classical hand-sorting method (Becking, 1957; Braun-Blanquet, 1964) and numerical syntaxonomy. In entering the data of coverage and environmental elements for relevé, raw table and partial table were made using [RIM] program (Kim and Kim, 2006) to minimize numerical errors, while for differential table and final differentiated table, syntaxon was drawn using [Ms-Excel]. In order to analyze the net contribution degree and appearance patterns of plant species for each plant community, relative contribution (*r-NCD)* to classified plant communities (Kim and Manyko, 1994) was calculated and prepared on the final differentiated table with quantitative relative values.

$$NCDi = \frac{\sum Ci}{N} \times \frac{ni}{N} \left(C\min \le NCD \le C\max \right)$$

$$r-NCDi = \frac{NCDi}{NCDmax} \times 100$$

$\sum Ci$: Integrated coverage for species i in the community

N : Number of total survey areas

ni : Number of survey areas where species i has appeared

$NCDi$: Contribution of species i to the subject community

NCD_{max} : Maximum contribution in the subject community

The classified Syntaxon was named for the International Code of Botanical Nomenclature (Theurillat et al., 2020). The standard plant names were recorded following the Korea Plant Name Index Committee (KPNIC, 2017).

III. Results and Discussion

1. Syntaxonomy and synecology of *Quercus variabilis* forest

1) *Quercus variabilis* community

Quercus variabilis community is the syntaxon identified by one differential species of *Quercus variabilis* and it is characterized by singly dominant *Quercus variabilis on* canopy. This community is mainly developing in the lower part of south-facing mountain slope with relatively steep inclination of 30 to 50° (average inclination: 33.7°). Rock exposure rate of this community is mostly under 25%, exhibiting plane micro-topography. Vegetation structure mostly represents four layers and coverage of herb layer is about 19%, relatively higher than other plant communities, but characterized by the small number of average appearance species (20.6 species). Such characteristic of herb layer is similar to that appearing in the habitat disturbed by persistent human intervention chiefly from compaction (Kim, 2008b). Besides, this community shows a high relative contribution of the plant species appearing mostly in secondary forest affected by human intervention, including *Rhus trichocarpa, Lespedeza maximowiczii, Diospyros lotus*, etc.

Thus, this community is considered a habitat maintained or continually disturbed by humans and a Korean rural forest managed by the village chiefly according to the characteristics mostly developing in the neighborhood of village and mountain area behind. Such a community species composition and habitat environmental condition make contrast to *Quercus variabilis* community identified by Song et al. (1999), Choung et al. (2006) and Choi and Kang (2006). This community, by appearance of cool-temperate southern·submontane-zone diagnostic species, such as *Ligustrum obtusifolium*, *Euonymus alatus* for. *ciliato-dentatus*, *Quercus serrata* etc. and mountain area revealing a low sea level, belonged to Callicarpo-Quercenion serratae of cool-temperate southern submontane zone (Kim, 1992).

2) *Platycarya strobilacea-Quercus variabilis* community

Platycarya strobilacea-Quercus variabilis community was classified by *Quercus variabilis*, *Platycarya strobilacea*, *Spodiopogon sibiricus*, etc. a plant community mentioned with a focus on cool-temperate southern-submontane zone syngeography (Lee et al., 2002; Jegal and Kim, 2003; Lee and Kim, 2017). This community representing 25-50% or over 50% rock exposure rate, exhibits *Deutzia parviflora*, *Chrysanthemum zawadskii* var. *latilobum*, etc. (Kim, 2008a) appearing from block stream, scree and outcrop due to high rock exposures. With a mean inclination of rather steep 35°, this community chiefly develops in uneven and protrusive micro-topography and south-facing slope. It usually shows a three-layer vegetation structure and this structure is considered due to the habitat's environmental condition including steep slope and uneven micro-topography. With average number of advent species 24, coverage of herb layer is relatively low 16.25%. This community illustrates three-layer community structure compared to *Quercus variabilis* community, but characteristically with low coverage of herb layer, which is considered due to settling difficulty of herb layer plant caused by shallow soil depth and absence of accumulated soil from sharp slope and high rock exposure rates. *Platycarya strobilacea-Quercus variabilis* community was mentioned by Lee and Kim(2017) as the vegetation type of drought-resistance and thermophilous dominant *Quercus variabilis* in the driest protrusive location of mountain ridge or steep-slope scree. Though the same classified species appears from the same environmental condition similar to this community, this community doesn't bring on *Sapium japonicum* (KNA, 2021) and *Fraxinus rhynchophylla*, etc. vulnerable to dryness, or *Fraxinus sieboldiana* (Kim, 2008b) appearing at a rock area exposed to winds. This community, according to the characteristics of plant species composition mostly appearing in the habitat environmental condition of high rock exposure, steep inclination and dry environmental condition (*Chrysanthemum zawadskii, Deutzia parviflora*, *Carex lanceolata*, *Pinus densiflora*, *Lindera glauca*, etc.) (Kim, 2005; Kim, 2008a; Kim, 2008b), was classified as the driest vege-

tation unit of *Quercus variabilis* forest distributed in Daecheong dam basin.

This community was classified as typicum subcommunity and *dictamnus dasycarpus* subcommunity by the difference in plant species composition, based on rock exposure rate and micro-topography.

Dictamnus dasycarpus subcommunity is the syntaxon with classified species of *Dictamnus dasycarpus, Securinega suffruticosa, Asplenium incisum*, etc. showing less than 25% of rock exposure rate and plane micro-topography, compared to typicum subcommunity. Its vegetation structure appears in three and four layers and develops in the central mountain slope. This subcommunity has around 77% canopy coverage, higher compared to typicum subcommunity (75%), with soil layer dotted with stones and pebbles less than 25cm. There is no emergence of *Rhus trichocarpa, Corylus sieboldiana, Diospyros lotus*, etc. (Cho and Kim, 2005; Kim, 2008b) chiefly developing in secondary forest with much human disturbance while such climbing plant as *Smilax china, Cocculus trilobus, Parthenocissus tricuspidata, Celastrus orbiculatus*, etc. don't appear, or has a low relative contribution. However, it is characterized by *Securinega suffruticosa* appearing in a high frequency due to vegetation structure with relatively high transmittance of canopy layer. Generally, *Dictamnus dasycarpus* is a plant species that comes into existence in the habitat with a dry soil condition (KNA, 2021), and it is a diagnostic species that well explains this subcommunity which shows a dry environmental condition of soil with a low soil depth layer and high transmittance.

3) Quercetum variabili-serratae Kobayashi, Muranaga et Takeda 1976

This association is a syntaxon with the diagnostic species of *Quercus variabilis* and *Quercus serrata*, mostly indicating the aspect of dominant *Quercus variabilis* on the canopy layer living in mixture with *Quercus serrata*. This association developing in Daecheong dam basin reveals 4-layer vegetation structure and plane micro-topography with diverse inclinations of 10 to 35°. Rock exposure rate being less than 10%, there are 18 average number of advent species less in number than *Quercus variabilis* community or *Platycarya strobilacea-Quercus variabilis* community. The first mention of Quercetum variabili-serratae was at Kansai region, Japan, and it was identified as the secondary forest of Quercetum variabili developing anticipatorily by natural disturbance in warm temperate region and cool-temperate submontane zone (Miyawaki and Okuda, 1990). This association was also mentioned on Imha dam, Andong (Song and Kim, 1993). Quercetum variabili-serratae is developing on the mountain slopes at dam water's edge just as that developing in the Daecheong dam basin. Though Quercetum variabili-serratae mentioned in Japan was mostly distributed in Camellietea japonicae Miyawaki et Ohba 1963, a warm-temperate zone, bringing on evergreen

broad-leaf trees and warm-temperate plant species, Song and Kim (1993) mentioned *Quercus variabilis* forest developing in Imha dam, Andong, as Quercetum variabili-serratae because the species appearing in Korea's cool-temperate zone *Quercus variabilis* forest, such as *Quercus variabilis*, *Quercus dentata*, *Platycarya strobilacea, Aster scaber*, *Smilax* spp., *Calamagrostis arundinacea, Carex lanceolata*, were also found to appear here. Quercetum variabili-serratae classified via this study was also mentioned as Quercetum variabili-serratae following Song and Kim (1993) characteristics of habitat environmental condition and similarity in plant species composition. Study area where this association is developing is a dam waters' edge and such phenomena as low diurnal range, regional season delay, dam area warming, etc. occur (Hong, 1982) and such environmental characteristics make contrast to Japan's oceanic climate. Thus, habitat in which this association can develop in Korea is syngeographically cool-temperate southern submontane zone of Callicarpo-Quercenion serratae vegetation(Kim, 1992). It is considered a habitat that can develop anticipatorily by natural disturbance on the hill slope of a reservoir's edge with water stored in like a dam.

4) *Zelkova serrata-Quercus variabilis* community

This plant community is classified with the species of *Quercus variabilis* and *Zelkova serrata.* The canopy height is over 12m and with dominant *Quercus variabilis, Zelkova serrata* is living in mixture, all showing relatively intact 4-layer forest structure. This community's habitat reveals uneven micro-topography and over 51% rock exposure rate, with a very sharp mean inclination of 47.5°. Coverage of herb layer is 7.5%, lower than other communities. This plant community developing in a valley area located at the lower part of hill slope is characterized by *Zelkova serrata* appearing in canopy, subtree layer and shrub layer and it has a low number of average appearance plant species (18 species) due to the absence of accumulated soil from a high rock exposure rate. Companion species to this community are mostly vulnerable to dryness, compared to other communities. They are *Quercus aliena, Fraxinus rhynchophylla, Philadelphus schrenckii*, *Acer pictum* subsp. *mono, Alangium platanifolium* var. *trilobum*, etc. appearing in a relatively damp environmental condition. These plant species mostly appear in a valley and marsh edge (Kim, 1992; Song, 2008). Besides, there is no climbing plant such as *Smilax china, Parthenocissus tricuspidata, Smilax sieboldii, Celastrus orbiculatus*, etc. that appears. This community, a valley-type *Quercus variabilis forest* developing in the Daecheong basin, shows the wettest environmental condition and a secondary forest, in which *Quercus variabilis* develops anticipatorily by natural disturbance, This is considered to turn into *Zelkova serrata* forest by natural succession.

5) *Dendranthema boreale-Quercus variabilis* community

This community was classified by *Quercus variabilis, Chrysanthemum boreale, Commelina communis, Prunus davidiana, Celtis sinensis*, etc. and it is a syntaxon with a singly dominant *Quercus variabilis* on canopy layer. Compared to other *Quercus variabilis* community, it has 3-layer vegetation structure and around 66% canopy coverage, the lowest of the six syntaxa. Coverage of herb layer is around 26%, relatively high. The habitat developing this community is on the hill slope of Daecheong dam water's edge where Quercetum variabili-serratae is developing, but with a characteristic difference that rocks are scattered on the mountain slope as in block stream. This habitat shows a very high rock exposure rate of over 70% and a sharp inclination of 40°. Due to a high rock exposure, sharp slope and shallow soil depth layer, this community shows the smallest number of average advent plant species of *Quercus variabilis* syntaxa classified in Daecheong dam, that is, about 17 species. Exhibiting a high rock exposure and a shallow soil depth, this community may have a dry condition of soil moisture, but developing on the mountain slope at the edge of Daecheong dam waters, it entails warming of atmospheric temperature caused by waters, many days of cloud and mist and a high air humidity such as fog. This allows diverse plant species to make appearance by means of moisture environment. Classified species of this community are also plant species appearing in wet environmental condition, which are living in mixture with *Artemisia gmelinii, Lespedeza maximowiczii, Quercus dentata, Carex humilis* var. *nana, Sedum kamtschaticum, Artemisia capillaris* (Kim et al., 2003; Kim, 2013). This community is considered a natural forest representing *Quercus variabilis* dominant persistent plant community that belongs to Callicarpo-Quercenion serratae (Kim, 1992), according to habitat position and environmental condition of human inaccessibility, edaphic characteristics of a high rock exposure rate and cool-temperate, southern, submontane zone plant species composition.

2. Phytosociological characteristics of *Quercus variabilis* forest in Daecheong-dam basin

The result of classifying the community of *Quercus variabilis* forest developing in the Daecheong dam basin produced a total of six syntaxa. Each syntaxa was classified by different plant species composition that reflects diverse topographical positions, including hill slope at the edge of waters, hill slope, hill slope around the village and mountain valley, rock exposure rate, inclination, moisture environment within survey area and the environmental conditions of the habitat. These syntaxa all signify the emergence of plant species which mostly appear in cool-temperate southern submontane zone (*Quercus serrata, Callicarpa japonica, Ligustrum obtusifolium, Euonymus alatus* for. *ciliato-dentatus,*

Table 1. Structured vegetation table of *Quercus variabilis* community and *Platycarya strobilacea-Quercus variabilis* community

A: *Quercus variabilis* community, B: *Platycarya strobilacea-Quercus variabilis* community, B-1: typicum subcommunity, B-2: *Dictamnus dasycarpus* subcommunity

	A								B																			
									B-1												B-2							
Running 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				
Relevé size(m²)	400	400	400	400	150	400	150	400	400	400	400	400	400	400	400	400	400	400	400	400	400	300	400	400				
Altitude(m)	290	203	215	239	237	116	136	205	225	325	118	303	186	236	135	158	106	298	354	338	182	520	153	232				
Slope direction	SSE	SW	S	E	SWV	SSE	W	S	SEE	SE	SSE	SEE	S	SW	SSW	NEE	S	S	NEE	NNW	SWV	SEE	SWV	SW				
Inclination(°)	35	30	30	30	30	50	30	35	25	25	70	65	25	35	30	25	35	30	30	25	30	20	50	40				
Number of species	14	18	17	18	25	26	25	22	22	24	28	23	22	21	27	26	23	26	25	24	22	26	27	21	A	B-1	B-2	B
Differential species of *Quercus variabilis* community																												
Quercus variabilis	9	8	9	8	9	8	9	8	8	8	8	8	8	9	8	8	8	8	9	8	9	8	8	8	100	100	100	100
Differential species of *Platycarya strobilacea-Quercus variabilis* typicum subcommunity																												
Platycarya strobilacea	·	3	·	·	·	·	·	·	5	2	5	3	4	3	3	6	2	1	3	4	5	4	5	·	0.55	41.84	31.82	39.36
Carex lanceolata	3	2	·	2	4	5	3	5	2	2	5	4	3	3	3	3	3	3	2	2	2	2	3	5	30.88	35.71	36.36	35.88
Spodiopogon sibiricus	2	·	2	2	·	2	·	·	·	2	2	2	2	2	5	2	3	2	·	·	2	3	2	2	5.88	16.84	27.27	19.23
Differential species of *Dictamnus dasycarpus* subcommunity																												
Dictamnus dasycarpus	·	1	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	2	·	·	2	6	3	2	0.18	0.17	39.39	3.58
Securinega suffruticosa	·	·	·	·	2	1	2	·	·	·	·	·	·	·	·	2	·	·	·	·	2	3	2	2	2.76	0.17	27.27	2.62
Asplenium incisum	·	1	·	·	·	1	·	·	·	·	·	·	·	·	·	·	·	·	·	·	2	·	2	2	0.74	·	13.64	0.86
Companion species																												
Lindera obtusiloba	2	2	2	4	4	4	5	3	6	4	·	6	2	3	3	3	5	3	3	6	·	3	2	2	38.24	41.16	15.91	34.06
Quercus serrata	6	4	5	4	·	3	·	5	4	2	·	4	6	2	5	3	4	5	2	3	4	·	2	3	29.78	37.41	20.45	32.73
Prunus sargentii	4	3	4	·	·	4	·	4	4	2	·	2	3	·	2	5	3	·	·	4	5	4	3	2	17.46	17.01	42.42	22.33
Ligustrum obtusifolium	·	·	·	·	3	2	2	2	2	·	·	2	2	2	2	2	·	3	2	2	2	3	2	2	6.62	14.54	27.27	17.37
Euonymus alatus f. *ciliato-dentatus*	·	3	2	1	3	2	2	3	·	·	·	2	3	2	·	2	·	·	·	2	2	3	·	2	20.59	4.68	15.91	6.87
Quercus aliena	·	3	·	·	·	4	·	3	2	·	·	4	2	·	3	3	3	·	2	3	·	8	5	3	5.51	14.97	36.36	19.94
Athyrium yokoscense	·	2	2	2	2	2	·	·	·	2	3	2	5	·	2	·	2	2	·	3	·	·	·	·	9.19	14.29	·	8.02
Rhus trichocarpa	·	·	3	2	2	2	2	·	·	2	·	2	·	·	·	2	·	3	3	2	·	2	·	·	10.11	7.14	1.52	5.34
Lespedeza maximowiczii	·	·	2	·	3	2	2	2	·	2	2	·	·	2	·	·	3	3	3	·	·	·	·	·	10.11	7.65	·	4.29
Melica onoei	·	·	2	2	3	·	3	·	2	2	·	·	2	·	3	3	3	·	2	·	·	·	·	·	7.35	10.12	·	5.68
Corylus sieboldiana	2	3	·	2	·	2	·	·	4	4	·	3	·	2	2	3	·	2	·	·	·	·	·	·	6.62	11.90	·	6.68
Smilax china	2	·	2	·	·	2	·	2	2	2	·	·	·	·	2	2	3	·	2	·	·	·	·	2	5.88	6.63	1.52	5.01
Cocculus trilobus	·	·	·	2	2	·	2	·	2	2	·	·	2	·	2	2	2	·	·	2	2	·	·	·	3.31	8.33	1.52	6.11
Oplismenus undulatifolius	·	1	·	1	2	·	·	·	·	·	·	·	4	2	2	·	·	·	3	1	2	·	5	3	2.21	5.10	22.73	8.40
Smilax sieboldii	·	·	2	2	·	·	·	·	·	2	2	1	·	·	·	2	·	2	·	·	2	2	2	·	1.47	3.83	13.64	5.73
Atractylodes ovata	·	1	·	1	2	·	·	·	·	·	·	·	2	2	2	3	·	2	2	·	·	·	·	·	2.21	6.63	·	3.72
Zanthoxylum schinifolium	·	·	2	·	·	·	·	3	3	·	·	·	2	2	·	·	·	3	2	·	·	·	3	2	1.84	5.10	7.58	5.68
Quercus acutissima	·	·	·	·	5	·	4	4	·	·	·	·	·	3	4	5	·	·	3	·	4	·	·	·	3.31	8.08	3.03	6.58
Ampelopsis heterophylla	·	·	·	2	2	·	2	2	·	·	2	·	·	·	2	·	·	·	2	·	·	·	2	·	5.88	1.53	1.52	1.53
Parthenocissus tricuspidata	·	·	2	·	·	·	2	3	2	·	3	·	·	·	2	·	·	·	·	·	·	2	·	·	3.86	1.79	1.52	1.72
Rhus javanica	·	·	·	·	2	2	2	·	·	·	·	2	·	·	2	·	3	·	·	·	·	3	·	·	3.31	1.79	2.27	1.91
Quercus dentata	·	2	·	·	1	·	2	·	·	·	2	·	·	·	2	·	·	2	·	·	·	·	·	·	2.76	1.53	·	0.86
Dioscorea tokoro	·	·	·	·	2	2	·	·	·	1	2	·	·	·	·	·	·	·	·	·	2	2	·	·	1.47	0.51	6.06	1.34
Callicarpa japonica	·	·	·	·	·	·	·	·	·	3	·	·	2	·	2	·	·	1	2	·	·	4	·	·	·	4.25	3.03	4.01
Aster scaber	·	·	·	·	·	·	·	2	2	·	·	2	2	·	·	·	·	·	2	·	·	·	2	·	0.37	2.72	1.52	2.39
Elsholtzia splendens	·	1	·	·	2	·	2	·	·	·	·	·	2	·	·	·	1	·	2	·	·	·	·	·	2.76	1.28	·	0.72
Dryopteris varia	·	2	2	·	·	2	·	·	·	·	·	2	2	·	·	·	·	·	·	·	2	·	·	·	3.31	0.68	1.52	0.86
Acer tataricum subsp. *Ginnala*	·	·	·	·	2	2	·	·	·	·	3	2	·	2	·	·	·	·	·	·	·	·	·	·	1.47	1.79	·	1.00
Juniperus rigida	·	·	·	3	·	·	·	·	·	·	·	·	·	3	2	·	1	·	2	·	·	·	·	·	0.55	2.72	·	1.53
Diospyros lotus	·	·	2	·	4	·	·	·	·	·	4	·	·	·	1	·	·	2	·	·	·	·	·	·	2.21	1.79	·	1.00
Albizia julibrissin	·	·	·	·	·	·	·	·	·	·	·	2	·	·	·	2	2	3	·	·	·	3	·	·	·	3.06	2.27	2.86
Celtis sinensis	·	·	·	·	·	·	2	·	·	·	·	·	·	·	·	·	·	·	2	·	·	3	2	3	0.37	0.17	18.18	1.91
Pinus densiflora	·	·	·	·	·	·	·	·	·	·	·	3	·	·	4	·	4	4	·	·	·	·	·	·	·	5.10	·	2.86
Lindera glauca	·	·	·	·	·	·	·	·	·	3	·	·	·	·	2	·	·	2	·	·	·	·	2	·	·	1.79	1.52	1.72
Lindera erythrocarpa	·	·	·	·	·	·	3	3	·	6	·	1	·	·	·	·	·	·	·	·	·	·	·	·	2.21	1.19	·	0.67
Celastrus orbiculatus	·	·	·	·	2	·	·	·	2	2	·	·	·	·	·	·	·	1	·	·	·	·	·	·	0.37	1.28	·	0.72
Rhododendron mucronulatum var. *ciliatum*	·	·	·	·	·	2	·	·	·	·	·	·	·	·	·	3	2	·	·	2	·	·	·	·	0.37	1.79	·	1.00
Isodon inflexus	·	·	·	·	·	·	·	2	·	·	·	·	·	·	·	·	·	·	·	1	·	2	1	·	0.37	0.09	4.55	0.57
Quercus mongolica	·	·	·	4	·	·	·	·	·	3	·	·	·	·	·	·	3	·	·	·	·	·	·	·	0.74	1.02	·	0.57
Ulmus parvifolia	·	·	·	·	·	·	2	·	·	·	3	·	·	·	·	·	·	·	·	·	·	·	·	2	0.37	0.26	1.52	0.48
Pteridium aquilinum var. *latiusculum*	1	·	·	1	·	·	·	·	·	·	·	·	·	·	·	2	·	·	·	·	·	·	·	·	0.74	0.17	·	0.10
Artemisia keiskeana	·	·	·	·	·	·	·	·	2	·	·	·	·	·	·	2	·	·	·	·	·	·	2	·	·	0.68	1.52	0.86
Castanea crenata	·	·	·	·	·	·	·	·	·	·	·	·	3	·	2	·	·	·	·	3	·	·	·	·	·	2.04	·	1.15
Akebia quinata	·	·	·	·	2	·	2	2	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	3.31	·	·	·
Ribes fasciculatum var. *chinense*	·	·	·	·	6	·	4	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	2	·	3.68	·	1.52	0.10
Polygonatum odoratum var. *pluriflorum*	·	·	·	·	·	·	·	·	1	·	·	·	·	·	·	·	·	1	·	·	·	·	·	1	·	0.34	0.76	0.43
Dryopteris lacera	·	·	·	·	·	·	2	3	·	·	·	·	·	·	·	·	·	·	·	2	·	·	·	·	1.84	0.17	·	0.10
Morus bombycis	·	·	·	·	·	2	2	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	2	·	1.47	·	1.52	0.10
Lespedeza maximowiczii var. *tomentella*	3	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	5	2	·	0.55	·	10.61	0.67
Styrax japonicus	·	·	3	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	3	·	·	0.55	·	2.27	0.14
Robinia pseudoacacia	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	4	·	·	·	·	2	·	·	0.34	1.52	0.57
Rubia akane	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	1	2	·	·	·	·	·	0.09	1.52	0.29
Pyrola japonica	2	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	1	·	·	·	·	·	0.37	0.09	·	0.05
Deutzia parviflora	·	·	·	·	·	·	·	·	·	·	2	·	·	2	·	·	·	·	·	·	·	·	·	·	·	0.68	·	0.38
Dendranthema zawadskii var. *latilobum*	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	3	·	3	·	·	·	·	·	·	1.02	·	0.57
Stephanandra incisa	·	·	·	·	·	·	·	·	·	·	·	1	·	·	·	·	·	·	·	·	·	2	·	·	·	0.09	1.52	0.29
Melampyrum roseum	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	4	·	1	·	·	·	·	·	·	·	0.85	·	0.48
Symplocos chinensis f. *pilosa*	·	·	·	·	·	·	·	·	·	3	·	·	·	·	·	·	2	·	·	·	·	·	·	·	·	0.85	·	0.48
Smilax nipponica	·	2	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	2	·	·	·	·	0.37	0.17	·	0.10
Polystichum tripteron	·	·	·	·	·	·	2	2	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	1.47	·	·	·
Styrax obassia	4	·	·	·	·	·	·	·	·	·	·	1	·	·	·	·	·	·	·	·	·	·	·	·	0.74	0.09	·	0.05
Cornus controversa	·	·	·	·	·	·	·	·	·	·	2	·	·	·	·	·	·	·	·	·	·	3	·	·	·	0.17	2.27	0.48
Carex ciliato-marginata	·	·	·	·	·	3	·	·	·	·	·	·	·	·	·	·	·	·	·	2	·	·	·	·	0.55	0.17	·	0.10
Phryma leptostachya var. *asiatica*	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	3	·	·	·	·	1	·	0.26	0.76	0.38
Zelkova serrata	·	·	·	·	·	·	·	·	3	·	·	·	·	·	·	·	·	·	·	·	·	·	·	5	·	0.26	3.79	0.76
Commelina communis	2	·	·	·	·	·	·	·	·	·	·	·	·	2	·	·	·	·	·	·	·	·	·	·	0.37	0.17	·	0.10
Artemisia gmelinii	·	·	·	·	2	·	·	·	·	·	·	·	·	2	·	·	·	·	·	·	·	·	·	·	0.37	0.17	·	0.10
Prunus davidiana	·	·	·	·	3	·	·	·	·	·	3	·	·	·	·	·	·	·	·	·	·	·	·	·	0.55	0.26	·	0.14

One occurrence species: running no. 1: *Larix kaempferi* 3(0.55); no. 6: *Boehmeria longispica* 2(0.37), *Euonymus oxyphyllus* 2(0.37); no. 7: *Rhododendron yedoense* f. *poukhanense* 2(0.37), *Corydalis speciosa* 2(0.37); no. 8: *Dendranthema horideje* 3(0.55), *Dryopteris saxifraga* 2(0.37); no. 9: *Carpinus laxiflora* 4(0.34), *Kalopanax septemlobus* 3(0.26); no. 10: *Sorbus alnifolia* 2(0.17), *Vaccinium hirtum* var. *koreanum* 2(0.17), *Lysimachia clethroides* 1(0.09); no. 11: *Fraxinus rhynchophylla* 2(0.17), *Sedum kamtschaticum* 2(0.17), *Davallia mariesii* 3(0.26), *Rosa multiflora* 2(0.17), *Clematis apiifolia* 3(0.26), *Rubus crataegifolius* 2(0.17), *Celtis aurantiaca* 2(0.17), *Fraxinus sieboldiana* 2(0.17), *Celastrus flagellaris* 2(0.17), *Crepidiastrum denticulatum* 1(0.09); no. 13: *Sambucus williamsii* var. *coreana* 3(0.26); no. 14: *Carpinus cordata* 3(0.26), *Lespedeza cyrtobotrya* 2(0.17); no. 16: *Disporum smilacinum* 1(0.09), *Vicia unijuga* 1(0.09); no. 17: *Miscanthus sinensis* var. *purpurascens* 1(0.09); no. 18: *Lonicera harae* 1(0.09), *Ainsliaea acerifolia* 1(0.09); no. 19: *Rubus parvifolius* 2(0.17); no. 20: *Ulmus davidiana* 2(0.17), *Betula davurica* 5(0.43), *Viola rossii* 1(0.09); no. 21: *Spiraea prunifolia* f. *simpliciflora* 2(1.52), *Thalictrum aquilegifolium* var. *sibiricum* 2(1.52), *Lactuca raddeana* 2(1.52), *Clematis terniflora* 2(1.52); no. 22: *Clematis brachyura* 2(1.52), *Hovenia dulcis* 2(1.52); no. 23: *Lonicera praeflorens* 2(1.52), *Spiraea blumei* 3(2.27); no. 24: *Maackia amurensis* 2(1.52)

GPS of releves: running no. 1:36° 32′ 31″ N, 127° 36′ 05″ E; no. 2: 36° 30′ 14″ N, 127° 35′ 26″ E; no. 3: 36° 21′ 12″ N, 127° 36′ 57″ E; no. 4: 36° 20′ 18″ N, 127° 32′ 40″ E; no. 5: 36° 28′ 45″ N, 127° 35′ 14″ E; no. 6: 36° 26′ 16″ N, 127° 35′ 05″ E; no. 7: 36° 22′ 56″ N, 127° 33′ 54″ E; no. 8: 36° 29′ 03″ N, 127° 38′ 06″ E; no. 9: 36° 14′ 47″ N, 127° 36′ 03″ E; no. 10: 36° 11′ 48″ N, 127° 33′ 38″ E; no. 11: 36° 23′ 43″ N, 127° 33′ 23″ E; no. 12: 36° 11′ 28″ N, 127° 34′ 26″ E; no. 13: 36° 26′ 58″ N, 127° 33′ 31″ E; no. 14: 36° 24′ 41″ N, 127° 41′ 15″ E; no. 15: 36° 28′ 53″ N, 127° 31′ 33″ E; no. 16: 36° 16′ 05″ N, 127° 32′ 35″ E; no. 17: 36° 28′ 18″ N, 127° 31′ 01″ E; no. 18: 36° 22′ 31″ N, 127° 27′ 12″ E; no. 19: 36° 11′ 22″ N, 127° 29′ 15″ E; no. 20: 36° 13′ 03″ N, 127° 39′ 51″ E; no. 21: 36° 18′ 31″ N, 127° 40′ 41″ E; no. 22: 36° 12′ 21″ N, 127° 35′ 44″ E; no. 23: 36° 17′ 38″ N, 127° 40′ 54″ E; no. 24: 36° 30′ 42″ N, 127° 28′ 43″ E

Table 2. Structured vegetation table of 3 syntaxa

C: Quercetum variabili-serratae Kobayashi, Muranaga et Takeda 1976
D: *Zelkova serrata-Quercus variabilis* community
E: *Dendranthema zawadskii* var. *latilobum-Quercus variabilis* community

	C				D				E					
Running No.	1	2	3	4	5	6	7	8	9	10	11			
Relevé size(m²)	400	400	400	400	400	400	225	225	150	150	150			
Altitude(m)	260	202	251	260	284	152	175	103	105	117	95			
Slope direction	SEE	S	SEE	NE	S	SW	SEE	SSE	SSW	SSW	SWW			
Inclination(°)	35	35	25	10	40	50	50	50	35	40	35			
Number of species	16	16	22	20	17	15	21	20	14	21	19	**C**	**D**	**E**
Diagnostic species of Quercetum variabili-serratae														
Quercus variabilis	8	8	8	8	8	8	8	9	9	8	7	100	100	100
Quercus serrata	4	4	5	5	5	·	·	·	·	·	2	56.25	3.79	2.78
Differential species of *Zelkova serrata-Quercus variabilis* community														
Zelkova serrata	·	·	·	·	4	7	5	4	·	·	·	·	60.61	·
Differential species of *Dendranthema zawadskii* var. *latilobum-Quercus variabilis* community														
Dendranthema boreale	·	2	·	·	·	·	·	·	4	3	6	1.56	·	54.17
Commelina communis	·	·	·	·	·	·	·	·	2	2	2	·	·	25.00
Artemisia gmelinii	·	·	·	·	·	·	·	·	6	3	3	·	·	50.00
Prunus davidiana	·	·	·	·	·	·	·	·	7	4	3	·	·	58.33
Celtis sinensis	·	·	1	·	·	2	·	4	2	5	5	0.78	9.09	50.00
Companion species														
Carex lanceolata	2	·	2	·	3	3	3	2	·	2	·	6.25	33.33	2.78
Lindera obtusiloba	3	3	7	·	6	·	3	2	·	·	·	30.47	25.00	·
Prunus sargentii	·	2	3	2	2	·	·	·	·	2	2	16.41	1.52	11.11
Melica onoei	·	2	2	·	2	·	·	·	3	2	·	6.25	1.52	13.89
Quercus acutissima	4	3	·	3	·	·	3	3	·	·	·	23.44	9.09	·
Platycarya strobilacea	·	·	·	·	·	4	4	5	·	·	2	·	29.55	2.78
Spodiopogon sibiricus	3	4	2	·	·	·	2	·	·	·	·	21.09	1.52	·
Ligustrum obtusifolium	·	·	3	2	·	1	·	2	·	·	·	7.81	4.55	·
Lespedeza maximowiczii	·	·	3	·	2	2	·	·	·	·	2	2.34	6.06	2.78
Athyrium yokoscense	·	·	·	2	1	2	2	·	·	·	·	1.56	11.36	·
Corylus sieboldiana	3	·	3	7	·	2	·	·	·	·	·	30.47	1.52	·
Pinus densiflora	4	4	4	3	·	·	·	·	·	·	·	46.88	·	·
Euonymus alatus f. *ciliato-dentatus*	·	3	·	·	·	2	2	·	·	·	·	2.34	6.06	·
Quercus aliena	·	2	·	·	5	·	2	·	·	·	·	1.56	10.61	·
Smilax china	2	2	·	2	·	·	·	·	·	·	·	14.06	·	·
Ampelopsis heterophylla	2	·	·	·	·	·	·	2	·	2	·	1.56	1.52	2.78
Parthenocissus tricuspidata	1	·	·	·	·	·	·	·	2	2	·	0.78	·	11.11
Lindera glauca	·	·	3	·	·	2	·	3	·	·	·	2.34	7.58	·
Lindera erythrocarpa	2	3	·	·	4	·	·	·	·	·	·	7.81	3.03	·
Quercus mongolica	5	·	5	·	·	·	·	·	·	2	·	15.63	·	2.78
Styrax japonicus	·	·	·	2	2	·	4	·	·	·	·	1.56	9.09	·
Robinia pseudoacacia	·	·	·	4	·	·	·	·	·	2	4	3.13	·	16.67
Quercus dentata	·	1	·	·	·	·	·	·	·	2	·	0.78	·	2.78
Rhus trichocarpa	·	·	·	·	2	·	·	·	·	·	2	·	1.52	2.78
Oplismenus undulatifolius	·	·	2	·	·	·	·	2	·	·	·	1.56	1.52	·
Smilax sieboldii	·	·	·	2	·	·	·	·	·	2	·	1.56	·	2.78
Atractylodes ovata	·	·	1	·	·	·	2	·	·	·	·	0.78	1.52	·
Zanthoxylum schinifolium	·	·	·	3	2	·	·	·	·	·	·	2.34	1.52	·
Rhus javanica	·	·	·	·	·	·	·	·	·	5	4	·	·	25.00
Acer tataricum subsp. *Ginnala*	·	·	·	2	·	·	3	·	·	·	·	1.56	2.27	·
Celastrus orbiculatus	·	·	·	2	·	·	·	·	·	·	2	1.56	·	2.78
Rhododendron mucronulatum var. *ciliatum*	·	2	·	·	3	·	·	·	·	·	·	1.56	2.27	·
Ulmus parvifolia	·	·	·	·	·	·	·	·	4	·	5	·	·	25.00
Fraxinus rhynchophylla	·	·	·	·	·	·	2	1	·	·	·	·	4.55	·
Lespedeza cyrtobotrya	2	·	1	·	·	·	·	·	·	·	·	4.69	·	·
Philadelphus schrenkii	·	2	·	·	·	3	·	·	·	·	·	1.56	2.27	·
Themeda triandra var. *japonica*	·	·	·	·	·	·	·	·	2	·	3	·	·	13.89

One occurrence species: running no. 1: *Pteridium aquilinum* var. *latiusculum* 1(0.78), *Pyrola japonica* 1(0.78); no. 3: *Juniperus rigida* 3(2.34), *Disporum smilacinum* 1(0.78), *Spiraea prunifolia* f. *simpliciflora* 1(0.78), *Vicia chosenensis* 1(0.78), *Viola collina* 1(0.78); no. 4: *Rhododendron yedoense* f. *poukhanense* 2(1.56), *Sorbus alnifolia* 2(1.56), *Acer palmatum* 2(1.56), *Convallaria keiskei* 2(1.56), *Castanea crenata* 3(2.34); no. 5: *Callicarpa japonica* 1(0.76), *Davallia mariesii* 1(0.76); *Maackia amurensis* 3(2.27), *Diospyros lotus* 2(1.52), *Asplenium incisum* 1(0.76); no. 7: *Acer pictum* subsp. *Mono* 3(3.79), *Acer pseudosieboldianum* 2(1.52), *Indigofera kirilowii* 2(1.52), *Deutzia parviflora* 2(1.52), *Alangium platanifolium* var. *trilobum* 2(1.52), *Persicaria filiformis* 2(1.52), *Hydrangea serrata* f. *acuminata* 1(0.76); no. 8: *Dictamnus dasycarpus* 2(1.52), *Akebia quinata* 2(1.52), *Rubia akane* 2(1.52), *Rubus oldhamii* 2(1.52), *Fallopia dentatoalata* 2(1.52), *Lonicera praeflorens* 2(1.52), *Aster scaber* 1(0.76), *Desmodium podocarpum* var. *mandshuricum* 1(0.76); no. 9: *Carex humilis* var. *nana* 3(4.17), *Artemisia keiskeana* 3(4.17), *Sedum kamtschaticum* 2(2.78), *Dianthus chinensis* 2(2.78); no. 10: *Dioscorea tokoro* 2(2.78), *Sambucus williamsii* var. *coreana* 2(2.78), *Boehmeria longispica* 2(2.78), *Rosa multiflora* 2(2.78), *Dioscorea batatas* 2(2.78); no. 11: *Coccullus trilobus* 3(4.17), *Artemisia capillaris* 2(2.78), *Prunus japonica* var. *nakaii* 2(2.78)

GPS of relevés: running no. 1: 36° 28′ 15″ N, 127° 32′ 51″ E; no. 2: 36° 23′ 42″ N, 127° 36′ 43″ E; no. 3: 36° 25′ 52″ N, 127° 40′ 34″ E; no. 4: 36° 13′ 51″ N, 127° 33′ 40″ E; no. 5: 36° 21′ 24″ N, 127° 32′ 52″ E; no. 6: 36° 24′ 42″ N, 127° 38′ 35″ E; no. 7: 36° 24′ 28″ N, 127° 35′ 53″ E; no. 8: 36° 22′ 57″ N, 127° 38′ 48″ E; no. 9: 36° 19′ 03″ N, 127° 41′ 05″ E; no. 10: 36° 18′ 56″ N, 127° 41′ 29″ E; no. 11: 36° 18′ 21″ N, 127° 39′ 41″ E

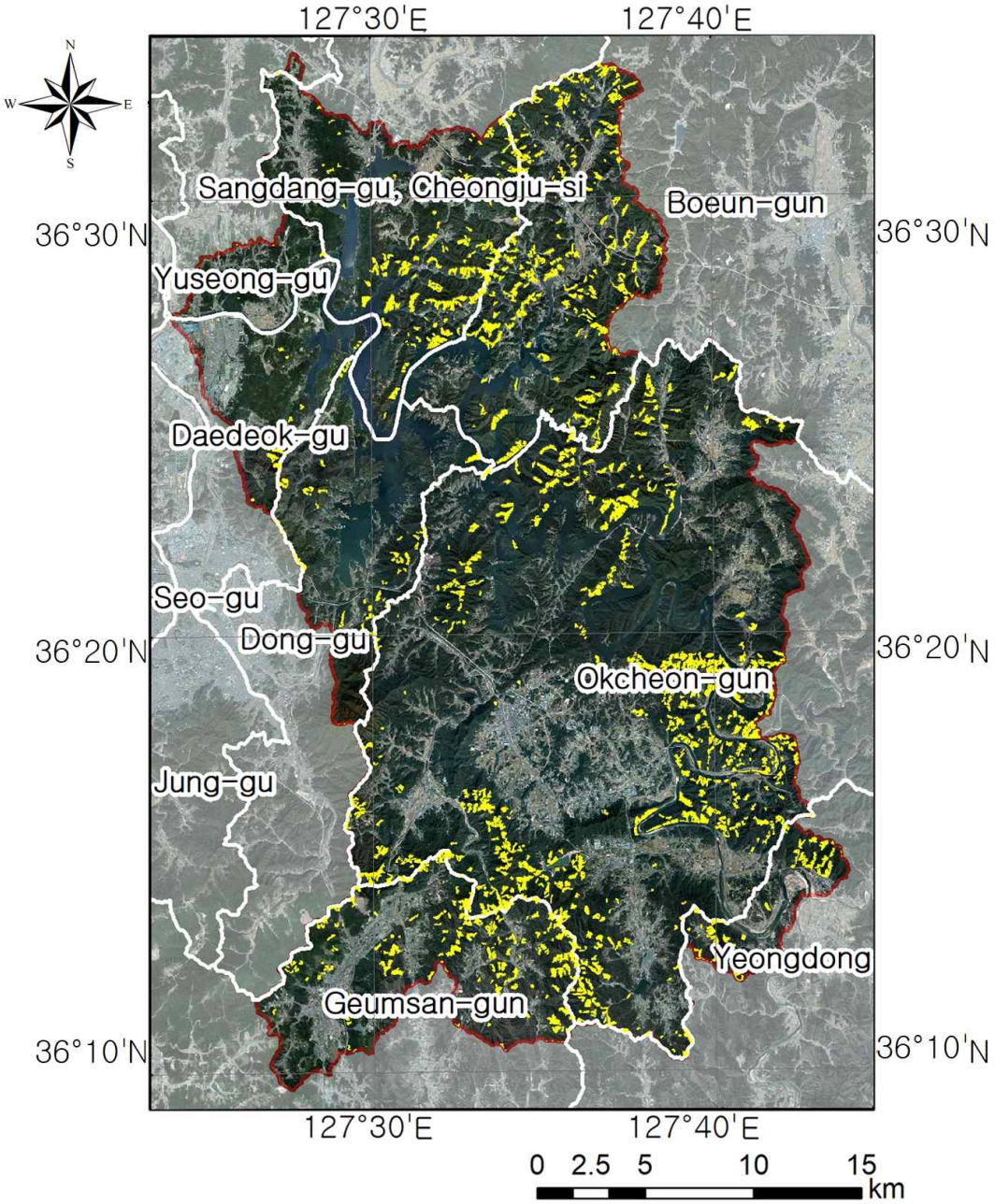

Figure 4. Distribution of Quercus variabilis forest in study area based on forest type map(NSDIP, 2021)

Quercus aliena, Celtis sinensis, etc.) and belonged to Callicarpo-Quercenion serrata(Kim, 1992). Generally, *Quercus variabilis* forest is distributed with a relatively large area in the syngeographical type of cool-temperate central-mountain Lindero-Quercion monogolicae chiefly with dominant *Quercus mongolica* forest (Kim and Kim, 2017). That's because *Quercus*

mongolica forest comes to represent canopy opened by natural or anthropogenic disturbance, and as light transmits into the forest, seed of *Quercus variabilis,* an intolerant tree, grows earlier than that of *Quercus mongolica,* a partial shade plant buried in the soil to make a forest (Song et al., 1999). Though Daecheong dam basin is in Choongcheong area, bioclimatically <central inland type> horizontally in mixture between cool-temperate southern submontane and central montane zone, it displays the characteristics of cool-temperate southern submontane zone plant species composition because there is hardly any mountain area with a high altitude in the survey area. Let's look at the flora of classified syntaxa. For the six syntaxa, the number of annual plant species comprise a total of seven classified groups (*Commelina communis, Corydalis speciosa*, *Elsholtzia splendens*, *Fallopia dentatoalata*, *Lactuca raddeana, Melampyrum roseum, Crepidiastrum denticulatum* etc.) which is very fewer than a total of 138 classified emergence groups (54 families, 94 genuses, 111 species, 22 varieties, 4 Forms, 1 subspecies), plant species except *Robinia pseudoacacia* and *Fallopia dentatoalata* are all wild plant species appearing in the wild of Korea. Habitat's environmental condition is commonly marked by human inaccessibility due to sharp inclination and a high rock exposure rate. Consequently, of the six syntaxa classified in the Daecheong dam, *Quercus variabilis* community exhibiting low diversity and relatively high cover of herb layer plant species by compaction was identified as a secondary forest by anthropogenic disturbance, four syntaxa, including *Platycarya strobilacea-Quercus variabilis* community (typicum subcommunity, *Dictamnus dasycarpus* subcommunity), Quercetum variabili-serratae, *Zelkova serrata-Quercus variabilis* community we re identified as a secondary forest by natural disturbance, and *Dendranthema boreale-Quercus variabilis* community as natural vegetation.

As to forest type map of our survey area Daecheong dam(Figure 4), *Quercus variabilis* forest is distributed in about 3,062 ha (6.8%) while for a single dominant tree, this has the fourth largest dominant forest area after *Pinus rigida* (5,243 ha, 11.1%), *Pinus densiflora* (4,311ha, 9.1%) and *Quercus mongolica* (3.972ha, 8.4%)(NSDIP, 2021). For *Pinus rigida* and *Pinus densiflora*, if seen as the forest originating from national afforestation project carried out in the 1970's (Kim, 2006), *Quercus mongolica* and *Quercus variabilis* which belong to *Quercus* spp. are forest community in natural succession up to now in a relatively large area of the target zone. Not only in the topographic area of protrusive micro-topography, mountain ridge and slope in its middle and upper part, rocky area in a mountain's sharp inclination (Kim and Yun, 2009; Yun et al., 2011; Byeon and Yun, 2017), is a piece of land in dominant *Quercus variabilis* also found in sedimentary rock and limestone zone without sharp inclination, indicating the bedrock experiencing water

stress and dryness (Choi, 2014; Shin et al., 2017). In view of such habitat environment, fine-grained soil mainly in metamorphic rock mainly exhibits the characteristic of appearing at habitat indicative of dry soil environmental condition. Syntaxa classified in Daecheong dam basin also indicates a bare rock signifying habitat environmental condition of sharp inclination and fine-grained soil mainly belonging to metamorphic rock, which is considered a factor of a relatively large area of forest to appear as the single tree kind of *Quercus variabilis*. By the way, of *Quercus variabilis* forest distributed in the Daecheong basin, most are developing in a mountain zone on the edge of waters, excepting a mountain distribution (Figure 4). *Quercus variabilis* forest developing on the mountain slope at the tip of waters is the secondary forest of Quercetum variabili-serratae and natural forest of *Dendranthema boreale-Quercus variabilis* community. *Quercus variabilis* forest is mainly distributed on the water's edge probably because, when the Daecheong dam was built in 1981, the central valley of the current waters and the middle and lower part of river and mountain area were subsided and, as on the water surface of dam mountain peak indicative of relatively sharp inclination and upper part of slope developed into *Quercus variabilis* forest by natural succession in a relatively large area. That is, by the geographical position of Daecheong dam basin and environmental condition of the habitat developing on the mountain area of the water's edge, *Quercus Variabilis* forest is characterized by Quercetum variabili-serratae and *Dendranthema boreale -Quercus variabilis* community.

IV. Conclusions

The six syntaxa identified via this study are developing on diverse mountain topography and geographical position including mountain slope on Daecheong dam water's edge, mountain area around the village, mountain valley, mountain slope, etc. According to difference in plant species composition by habitat's environmental condition including topographical characteristics, water environmental condition of soil and atmosphere, inclination and rock exposure, totally six syntaxa were mentioned: *Quercus variabilis* community, *Platycarya strobilacea-Quercus variabilis* community (typicum subcommunity, *dictamnus dasycarpus* subcommunity), Quercetum variabili-serratae, *Zelkova serrata-Quercus variabilis* community, *Dendranthema boreale-Quercus variabilis* community, etc.) *Quercus variabilis* forest on Daecheong dam mostly faces south and develops in the mountain slope with over 30° sharp inclination. These syntaxa all reverted to Callicarpo-Quercenion serratae due to the characteristics of cool-temperate southern submontane plant species composition. Of the six syntaxa of plant species composition, the plant community indicating the wettest environmental condition was found to be *Zelkova serrata-Quercus variabilis*

community, and the driest environmental condition to be *Platycarya strobilacea-Quercus variabilis* community. Though *Platycarya strobilacea-Quercus variabilis* community refers to topographical environment meaning similar high rock exposure and shallow soil depth compared to *Dendranthema boreale-Quercus variabilis* community, the latter was identified as another plant community name by difference in species composition due to high air humidity as it develops on Daecheong dam water's edge. Though *Dendranthema boreale-Quercus variabilis* community is developing on the mountain slope at Daecheong dam water's edge, the same as Quercetum variabili-serratae, each was classified by difference in plant species composition due to topographical characteristics of a high rock exposure rate. For plant community representing Daecheong dam basin, the natural forest of *Dendranthema boreale-Quercus variabilis* community and the secondary forest of Quercetum variabili-serratae were mentioned. It was found that *Quercus variabilis* forest distributed in Daecheong dam has been in relatively good natural succession by the habitat's environmental condition of plant species composition of wild plants, low appearance rate of annuals and inaccessibility. *Quercus variabilis* community was found to be a secondary forest maintained by human disturbance, *Platycarya strobilacea-Quercus variabilis* community (typicum subcommunity, *dictamnus dasycarpus* subcommunity), Quercetum variabili-serratae and *Zelkova serrata-Quercus variabilis* community to be the secondary forest by natural disturbance, and *Dendranthema boreale-Quercus variabilis* community to be a natural forest signifying *Quercus variabilis* forest persistent plant community. *Quercus variabilis* forest developing in the Daecheong dam basin was verified to be mainly developing on mountain slope on water's edge excepting a mountain zone. Such a distributive characteristic seems to have been caused by topographical characteristics of mountain- edge zone (Mountain peak and upper slope with a sharp inclination) exposed by Daecheong dam construction. Therefore, it is considered that *Quercus variabilis* is suitable for the restoration of oak trees on steep slopes in the Daecheong Dam basin. Results of syntaxonomy and synecology on the 6 syntaxa of *Quercus variabilis* forest identified via this study can be provided for data to compare with ecological characteristics of *Quercus variabilis* forest developing in dam regions except the Daecheong dam. It is expected that these results will be utilized as research data to the vegetation hierarchical systems of *Quercus variabilis* forest in Choongcheong-do area.

References

Bae KH · Lee JH and Kim DG. 2005. Vegetation Composition and Structure of Mt. Kumbong, Uiseong-Gun, Korea. Korean Journal of Agricultural and Forest Meterology 7(4): 303-310. (in Korean with English summary)

Becking RW. 1957. The Zürich-Montpellier School of Phytosociology. Bot. Rev. 23: 411-488. (in English)

Braun-Blanquet J. 1964. Pflanzensoziolgie(3rd ed.). Wien: Springer. (in English)

Byeon SY and Yun CW. 2017. Vegetation Type and Stand Characteristics of Nature Forest in Mt. Janggunbong, Bonghwa-Gun. Korean J. Environ. Ecol. 31(3): 297-317. (in Korean with English summary)

Cho KJ and Kim JW. 2005. Syntaxonomy and Synecology of the *Robinia pseudoacacia* Forest. Korean J. Ecol. 28(1): 15-23. (in Korean with English summary)

Choi BK. 2014. Actual Vegetation of Dodamsambong (Scenic Site no. 44) and Danyangseokmoon (Scenic Site no. 45) in Danyang-gun. Journal of the Korean Institute of Traditional Landscape Architecture 32(2): 116-123. (in Korean with English summary)

Choi SH and Kang HM. 2006. Vegetation Structure of the Kumsaenggol in the Wolchulsan National Park. Kor. J. Env. Eco. 20(4): 464-472. (in Korean with English summary)

Choung HL · Chun YM and Lee HJ. 2006. Progressive Succession and Potential Natural Vegetation on the Forest Vegetation in and surrounding Daegu, Korea. J. Ecol. Field Biol. 29(3): 265-275. (in Korean with English summary)

Hong SG. 1982. Increase of the Fogs in Andong due to the Construction of Andong Reservoir. Asia-Pacific Journal of Atmospheric Sciences. 18(2): 26-32. (in Korean with English summary)

Hwang SM and Yun CW. 2007. Vegetation Structure of Secheon Valley Area and Forest Vegetation Types in Mt. Sikjang. Korean J. Environ. Biol. 25(3): 249-259. (in Korean with English summary)

Jegal JC and Kim JW. 2003. A Phytosociological Comparison of Forest Vegetation between Igneous and Sedimentary Rock Areas in Kyungpook Province, South Korea. Korean J. Ecol. 26(1): 23-28. (in Korean with English summary)

Ji YU · Lee MJ · Kim HJ · Lee KS · Yee S and Song HK. 2003. Classification and Analysis of Community Structure of Jinaksan Forest in Geumsan. Korean J. Environ. Biol. 21(3): 262-270. (in Korean with English summary)

Kim BM and Yang KC. 2017. Studies on major plant communities distribution factors of the Gayasan national park using GIS. Journal of Wetlands Research 19(1): 164-171. (in Korean with English summary)

Kim CH and Kim MS. 2008. Vegetation and Community Similarity of Mt. Kookmang. Korean Journal of nature conservation 6(1): 21-29. (in Korean with English summary)

Kim HJ · Lee MJ · Ji YU · An SM · Lee KS and Song HK. 2002. Forest Community Classification of Dodeokbong and Baekwunbong in Daejeon. Korean J. Environ. Biol. 20(3): 216-223. (in Korean with English summary)

Kim HJ and Yun CW. 2009. A Study on the Forest Vegetation Classification and Analysis of Interspecific Association in Mt. Munsu and Mt. Okseok. Jour. Korean For. Soc. 98(4): 379-391. (in Korean with English summary)

Kim HS · Kim IS · Hong KH · Kim NY · Park KS · Kim JY and Park WG. 2003. A Study on the Flora and Community Classification of Forest Vegetation in the Mt. Yumyeong. F. For. Sci. Kangwon Nat'l Univ. 19: 68-84. (in Korean with English summary)

Kim HS · Lee SM and Song HK. 2010. An Analysis of the Vegetation on the Southern and Northern Slopes in the Deogyusan National Park. Kor. J. Env. Eco. 24(5): 601-610. (in Korean with

English summary)

Kim HS · Lee SM and Song HK. 2011. Actual Vegetation Distribution Status and Ecological Succession in the Deogyusan National Park. Kor. J. Env. Eco. 25(1): 37-46. (in Korean with English summary). (in Korean with English summary)

Kim IT · Lee JH and Jin YG. 2000. The Vegetation of Hansan and Chubong Islets. Korean J. Ecol. 23(5): 391-395. (in Korean with English summary)

Kim IT · Park TH and Choi JE. 2005. An Ecological Study on the Vegetation of Bijin and Yongcho Islets. Korean J. Ecol. 28(4): 223-230. (in Korean with English summary)

Kim JW. 1992. Vegetation of Northeast Asia: On the syntaxonomy and syngeography of the oak and beech forests. Ph.D. dissertation, University of Vienna. (in English)

Kim JW. 2005. What is the problem with Korean pine trees seen through forest fires on the east coast and pinewilt disease. Korean J. Ecol. 28(2): 113-120. (in Korean)

Kim JW. 2006. Vegetation Science(2nd ed.). Seoul: World Science. (in Korean)

Kim JW. 2013. The Plant Book of Korea: Vol. 1. Plants Living Close to the Village. Seoul: Nature & Ecology. (in Korean)

Kim JW · Choi BK · Ryu TB and Lee GY. 2012. Application and assessment of national vegetation naturalness, pp. 81-172. In: Guideline for the 4th national survey for natural environment. National Institute of Environmental Research, Inchon, Korea. (In Korean)

Kim JW and Kim SY. 2006. Vegetation Classification-Computer program [RIM] ver. 2.1. Korean Institute of Ecosystem Management. (in Korean)

Kim JW · Lee DI and Kim W. 1995. Minimal Areas and Community Structures of *Pinus densiflora* Forests and *Quercus mongolica* Forests. Korean J. Ecol. 18(4): 451-462. (in Korean with English summary)

Kim JW and Lee YK. 2006. Classification and Assessment of Plant Communities. Seoul: World Science. (in Korean)

Kim JW and Manyko YI. 1994. Syntaxonomical and synchorological characteristices of the cool-temperate mixed forest in the Southern Sikhote Aline, Russian Far East. Kore. J. Ecol. 17: 391-413. (in English)

Kim K and Jeong Y. 2006. Variations of Annual Evapotranspiration and Discharge in Tree Different Forest-Type Catchments, Gyeonggido, South Korea. Korean J. Agricultural and Forest Meteorology. 8(3): 174-182. (in Korean with English summary)

Kim MS. 2008a. Outcrop vegetation in central-northern Youngnam region. MS dissertation, Keimyung University. (in Korean with English summary)

Kim SY. 2008b. The Vegetation of Mt. Ap-san in Daegu. MS dissertation, Keimyung University. (in Korean with English summary)

Kim YH and Kim JW. 2017. Ditributional Uniqueness of Deciduous Oaks(*Quercus* L.) in the Korean Peninsula. J. Korean Env. Res. Tech. 20(2): 37-59. (in Korean with English summary)

KMA(Korea Meteorological Administration). 2021. Weather data opening Potal. Korean Meteorological Administration. http://data.kma.go.kr/(accessed 25. Jan. 2021)

KNA(Korea National Arboretum). 2021. Korea Biodiversity Information System. Korea National Arboretum. http://www.nature.go.kr/main/Main.do (accessed 5. Apr. 2021)

KPNIC(Korean Plant Names Index Committee). 2017.

Checklist of Vascular Plants in Korea. Pocheon: Korea National Arboretum. (in Korean)

Lee BC and Yun CW. 2002. A Study on Community Classification of Forest Vegetation in Mt. Naeyeon. Korean J. Ecol. 25(2): 83-91. (in Korean with English summary)

Lee CH and Park SH. 2008. The Flora and Vegetation of Mt. Palkong in Jangsu. Journal of the Korean Institute of Forest Recreation 12(4): 27-38. (in Korean with English summary)

Lee GY and Kim JW. 2017. Oak Forests of the Daegok-cheon Petroglyphs Area in Ulsan, South Korea. KJEE 50(1): 126-136. (in Korean with English summary)

Lee JH · Bae KH and Cho HJ. 2006. Forest Vegetation Classification and Species Composition of Mt. Ilwol, Yeongyang-Gun, Korea. Korean Journal of Agricultural and Forest Meteorology. 8(3): 132-140. (in Korean with English summary)

Lee MJ · Yee S · Kim HJ · Ji YU and Song HK. 2002. Vegetation Structures and Ecological Niche of Quercus variabilis Community. Jour. Korean For. Soc. 91(4): 429-438. (in Korean with English summary)

Lee SJ · Ohno K and Ahn YH. 2011. Study of Anlaysis of Vegetation Structure and Species Diversity for Vegetation Management on Shrine Forest of Miwhang-sa, Korea. Kor. J. Env. Eco. 25(4): 540-561. (in Korean with English summary)

Miyawaki A and Okuda S. 1990. Vegetation of Japan Illustrated, 620p. Tokyo: Shibundo co publishers. (in Japanese)

NSDIP(National Spatial Data Infrastructure Potal). 2021. Forest Type Map. Ministry of Land, Infrastructure and Transport. http://data.nsdi.go.kr/dataset/20190716ds 00001/ (accessed 25. Apr. 2021)

Oh HS · Lee GY and Kim JW. 2018. Syntaxonomical and Synecological Description on the Forest Vegetation of Juwangsan National Park, South Korea. Koeran J. Environ. Ecol. 23(1): 118-130. (in Korean with English summary)

Shin JK · Byeon JG · Yun CW · Koo BY · Kim HG · Kim IS and Kim DK. 2017. Forest Community Classification and Vegetation Structure in National Yonghyeon Natural Recreation Forest. Korean J. Environ. Ecol. 31(2): 220-229. (in Korean with English summary)

Song JS. 2008. A Synecological Study of the Riverside Vegetation of the Upper Stream of Nakdong River, Korea – I. Forest and Shrub Vegetation -. Kor. J. Env. Eco. 22(4): 443-452. (in Korean with English summary)

Song JS and Kim HK. 1993. Synecological Study on the Forest Vegetation of Imha-dam Area, Andong. Korean J. Ecol. 16(4): 439-457. (in Korean with English summary)

Song JS · Roh KS · Chung WS · Song SD · Ohno K and Mochida Y. 1999. Phytosociological Study of the Forest Vegetation in the Mountainous Areas of the Morthern Part, Kyungpook Province using the Methodology of Physiognomy and Numerical Syntaxonomy. Korean J. Ecol. 22(5): 241-254. (in Korean with English summary)

Theurillat JP · Willner W · Fenrnández-González F · Bültmann H · Čarni A · Gigante D · Mucina L and Weber H. 2020. International Code of Phytosociological Nomenclature(4st ed.). Applied Vegetation Science. https://doi.org/10.1111/AVSC.12491. (in English)

Westhoff V and Van der Maarel E. 1973. The Braun-Blanquet Approach. In. R. H. Whittaker (ed.), Ordination and Classification of Communities. Dr. W. Junk, The Hague.

pp.617-726. (in English)

Yoo YS. 1993. A Study on the Stratigraphy and Geologic Time of the so-called Okcheon System in Cheongseongmyeon area, Okcheongu, Chungcheongbuk-do. MS dissertation, Chungnam National University. (in Korean with English summary)

Yun CW · Kim HJ · Lee BC · Shin JH · Yang HM and Lim JH. 2011. Characteristic Community Type Classification of Forest Vegetation in South Korea. Jour. Korean For. Soc. 100(3): 504-521. (in Korean with English summary)

Yun CW · Oh SH · Lee JH · Joo SH and Hong SC. 1999. Prediction of Succession and Silvicultural Contro in the Black Locust(Robinia pseudoacacia L.) Plantation. Jour. Korea For. Soc. 88(2): 229-239. (in Korean with English summary)

Yun CW · Oh S · Lee YG · Hong SC and Kim JH. 2001. The Study on the Invasion of *Robinia pseudoacacia* into Stand Structures and Vegetation Units. Jour. Korea For. Soc. 90(3): 227-235. (in Korean with English summary)

Yun JW · Jung SC · Koo GS · Lee JH · Yun CW and Joo SH. 2010. Forest Vegetation Classification on Sobaeksan National Park in the Baekdudaegan. Kor. J. Env. Eco. 24(6): 630-637. (in Korean with English summary)