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Species Composition and Structure of the Oriental Arbor-vitae (*Thuja orientalis* L. Forest in Daegu, Southeastern Korea

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ABSTRACT : The floristic composition and structure of the Oriental Arbor-viate forest, natural monument no.1, were investigated in the Daegu city, southeastern Korea. Vegetation stratification have four layers including tree (>5m), subtree (2m-5m), shrub (1m-2m) and herbs (<1m), which occupied 63.8%, 10.7%, 12.1% and 49.4%, respectively. The vegetation of the study area were divided into *Artemisia keiskeana* - *Quercus variabilis* and *Pyrrosia linearifolia-Thuja orientalis* (OAV) communities. Frequency distribution for diameter classes of the Oriental Arbor-vitae population showed a reverse-J shape. The result suggests that the OAV forest of this site might maintains continuously the present state. The annual radial growth of OAV, *Pinus densiflora* and *Quercus variabilis*, the dominant species of the present site showed 0.29, 1.01 and 1.28 mm/year, respectively. Competition of OAV with the other species including *P. densiflora* and *Q. variabilis* could influence negatively on the growth and survival of OAV forest in this site.

Key words: Annual radial growth, Diameter classes, Oriental Arbor-vitae forest, Vegetation structure

INTRODUCTION

Species composition of forest vegetation and structure change with time. The changes of vegetation characteristics with time are related to interactions between individual plants, plants and environments, or plants and animals, but these mechanisms are very difficult to clarify. It is very important to detect and understand those mechanisms and the structural characteristics of it for management of the natural forest. That is, understanding structure and dynamics of the forest in a given area is a prerequisite to prepare conservation, protection and restoration strategies of it.

Oriental Arbor-vitae (OAV) is a valuable and representative conifer growing on the limestone or shale of rich limes in Korea. OAV is recognized as an ornamental conifer, which are slow-growing and conical. It grows locally on steep rocky streamside or often cliff, in West China and Korea. It shows high tolerance to low temperature and grows well on dry and freely drained sites like alkaline soil. It was mostly designated as the natural monuments due to its scientific value and rarity in Korea. It was found in Danyang (Natural monument No.62), Yeongyang (Natural monument No.114), Uljin (Natural monument No.155) and Andong (Natural monument No.250) in Korea.

There are few studies on vegetation occurring on cliff faces like OAV forest throughout the world, due in part to the hazards involved in sampling, and the perception that cliff faces, like high arctic tundra are relatively unproductive and stressful habitats for plants. Several studies on cliff vegetation were carried out on limestone formations (Hepburn 1943, Jackson and Sheldon 1949, Wilson and Cullen 1986, Escudero 1996), but practical examination on the structure and composition of the forest vegetation of cliff is very rare.

The main objectives of the study were to clarify the characteristics of the vegetation structure of Arbor-vitae forest located on Daegu city as natural monument no. 1, southeastern Korea from the viewpoint of conservation ecology and to provide the useful information necessary for determining the community unit.

STUDY AREA AND METHODS

The study area is located in Do-dong of Daegu city, southern Korea (lat. 35°53'N, long. 128°37'E) (fig. 1) and was designated as a natural monument No. 1 in Dec. 1962. The OAV foreound the Gwaneumsa temple, a branch of Donghwasa temple. The geology is mainly consisted of metamorphic rock (hornfels or shale) with rich lime. OAVs are hanging on the Cliff here and there, forming groups.

This site is very dry and the temperature difference through a year is extreme. Meteorological data of Daegu near to the study area show 1,030.6 mm and 13.2 ℃ in mean annual precipitation and temperature (Max: 40℃,1942. 8. 1 / Min: -20.2℃, 1923. 1. 19), respectively (KMA 1990-2000). Whereas the warmth and coldness indices (WI and CI) (Kira 1948), reckoned from data

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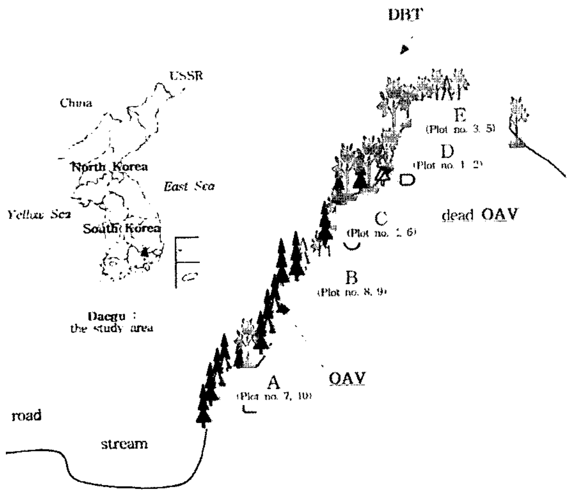

Fig. 1. A map showing the location of the study area and cross-sectional view of sampled plots. OAV Oriental Arbor-vitae, DBT: Deciduous broad-leaved tree.

obtained in Daegu (47.9 a.s.l.) (Daegu Meterological station, 1990-2000), range from 114.6 WI (-9.9 CI) to 119.4 WI (-8.7 CI) (degree.month), suggest that this area corresponds to the temperate deciduous forest zone(Kira 1948).

The cliff supports a self-sustaining OAV forest, which includes some trees 300 years old. Approximately 75 percent of the study area is covered with the OAV population more than 150 years old. Although most of the forests have been occupied by the OAV, approximately two-fifth of the forests are mixed with deciduous broad-leaved tree species such as *Quercus* spp., *Platycarya strobilacea* and so on.

The OAV population is almost entirely restricted to steep slopes near the stream in the study area. The upper canopy of the OAV populations rarely reaches 5~7m in height on the steep slopes or 9m on the less inclined ground. As the undergrowth, a number of ferns are typical of the rocky outcrops and dry sites of the scarps, *Selaginella tamariscina* and *Pyrrosia petiolosa* are amongst the most common ones. In the upper slope area, the OAV populations are in the process of replacement by *Quercus* spp. Generally, the layer of herbs and shrubs is less developed than in the other forest communities due to the harsh site conditions.

Fieldwork was carried out from May to September, 2000. Five sites were chosen subjectively at the altitudes A, B, C, D and E. Two plots in size 10m ×10m, were set within each sites. Site A was located on the top, site B was on the upper part of the slope, sites C and D were on the middle part of the slope, and site E was on the lower part of the slope. The location of the study area and sampled plots are shown in Fig. 1.

Vegetation type classification was accomplished by the floristic-structural releves, which were established by using the floristic-physiognomic approach introduced by Braun-Balanquet (Braun-Blanquet 1964, Muller-Dombois & Ellenberg 1974). At each plot, all vascular plants were listed and assessed for dominance in six degree (+ to 5) and sociability in five degree (1 to 5). Species nomenclature followed Lee (1985). Vegetation stratification divided into tree layer, subtree layer, shrub layer and herbs layer, and investigated coverage in each stratification.

To analyze the structural characteristics of the major populations, diameter at breast height (DBH) and the number of individuals for all trees within several plots (plot no. 1,5,6,8,9 in Fig. 2) were measured (>2cm DBH) and counted. Vegetation dynamics were analyzed by the frequency distribution diagrams of diameter classes of major tree species. In addition, several trees composed the forest were cored to determine the approximate age and annual ring growth of the mature trees. The number and width of rings were counted and measured after grinding by sand paper in laboratory. The ages based on these cores are conservative because the pith is difficult to collect on large trees, and cores were collected at approximately one-meter height.

RESULTS AND DISCUSSION

Vegetation stratification and composition

Oriental Arbor-vitae occupied for approximately 75 percent of the study area; because of its clear dominance, species diversity was low. The evergreen herbs like *Selaginella tamariscina, Pyrrosia linearifolia, Camptosorums sibiricus* etc. formed a distinct and characteristic component of the community. The harsh environment on the cliff reduce competition with more stable site-demanding species. Another major species are *Quercus variabilis* and *Platycarya strobilacea*, an aggressive tree that sometimes behaves as substitute species for Oriental Arbor-vitae.

Fig. 2 showed the stratification diagram of the Oriental Arbor-vitae community (plot no. 7-no. 10). Vegetation stratification have four layers including tree (>5m), subtree (2m-5m), shrub (1m-

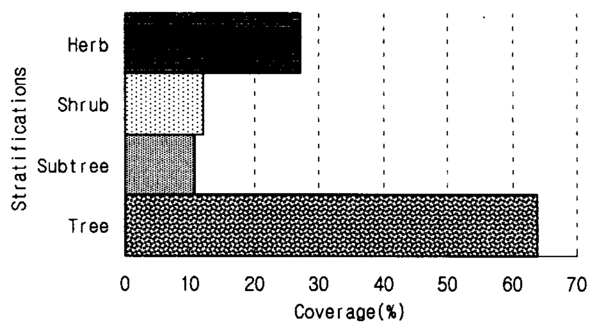

Fig. 2. Stratificaton profile of the OAV community.

2m) and herbs (<1m), which occupied 63.8%, 10.7%, 12.1%, 49.4%, respectively. Compared with the other communities, shrub and herbs layer showed very low coverage, this seems to be regard with the harsh site conditions like the cliff.

Species composition

Table 1 shows the species composition of the Oriental Abor-vitae forest. According to the Table 1, the OAV forest was divided into *Artemisia keiskeana - Quercus variabilis community*, of which the differential species was *Sedum kamtschaticum, Artemisia keiskeana, Q. serrata, P. strobilacea, Carex ciliato-marginata, Sorbus alnifolia and Polygonatum odoratum* var. *pluriflorum*, and *Pyrrosia linearifolia-Thuja orientalis*(OAV) community type. *Quercus variabilis* with a height of 3~9m constituted the layer above the shrub and showed high vitality, and this community was found from the middle to the upper part of the slope. It tends to extend sporadically within the OAV populations. *Selaginella tamariscina, Q. variabilis, Pyrrosia petiolosa, Thuja orientalis, Sedum kamtschaticum, Atractylodes japonica, Fraxinus rhynchophylla, Lactuca raddeana, Lindera obtusiloba and Indigofera kirilowii* etc. occurred frequently in the area as the constancy classes are above Ⅲ.

Population Structure of OAV and other major trees.

As several authors have pointed out, component species respond to disaster or disturbance with various forms of vegetative reproduction and play an important role in forest regeneration(Forcier, 1973; Marks, 1974; Horn, 1975; Harper, 1977; Halle *et al.*, 1978; Grime, 1979; Bormann and likens, 1979; Oliver, 1981).

The size variation of individuals is an important aspect for describing community structure: it also indicates the establishment process, shade tolerance and succession trends of a population (Okitsu *et al.* 1995) and from which the interspecies relationship can be derived. Fig. 3 showed the frequency distribution of diameter classes of the three most representative community types in the study area: OAV community (Type Ⅰ; A and B in Fig. 3), Mixed forest (Type Ⅱ; C) and *Quercus variabilis* community (Type Ⅲ; D and E).

Type Ⅰ showed the highest proportion in the DBH 5cm-10cm, which was dominated by the OAV and showed another peak in <2cm. A (in Fig. 3) indicated that the OAV dominated all diameter classes. This result implies that the community can be sustained for a time being in keeping *Q. variabilis* recently intruded within the community. B showed the similar tendency to the A, although some other species, such as *Fraxinus rhynchophylla, Q. variabilis* and *Platycarya strobilacea* were invaded below the subtree layer. Frequency distribution of DBH classes of the OAV showed a reverse-J shape. This result suggested that the OAV of this site might maintained continuously the present state. Type Ⅱ(C) showed that the OAV were in interspecific competition with *Q. variabilis* and other tree species. Type Ⅲ(D and E) showed that OAV was replaced by the deciduous species, such as *Quercus variabilis, Strobilacea Platycarya*, and *Fraxinus rhynchophylla*. Therefore, a conservation strategy like removing the competing trees, supplementary planting, and fostering of successor trees was required to maintain the OAV community in this site.

Growth of annual ring width

To analyze the growth of annual ring of the major tree species in the study sites, we selected OAV, *Q. variabilis* and *Pinus densiflora* as a sample trees. Cores of these major species were taken from stem of 30cm above ground level.

The resulting linear regression equations for the prediction of cumulative radial growth patterns were as follow:

Thuja orientalis(OAV) : $lnY=-2.987086+0.930468lnX$ ($R^2=0.8574$)
Pinus densiflora : $lnY=-2.507236+1.320395lnX$ ($R^2=0.8160$)
Quercus variabilis : $lnY=-1.094738+0.852377lnX$ ($R^2=0.9904$)

According to the previous studies, Mean radial growths for the *Abies koreana* on Mt. Kaya and *Pinus densiflora* on the cliffs of Sangju area showed 0.82mm/year and 1.38mm/year in radius, respectively (Bae 1994). Mean radial growth of OAV showed 0.29mm/year. This result showed that the radial growth of OAV was very slow compared with other species including *Abies koreana* and *Pinus densiflora* grown on the barren sites of in Korea.

Radial growth of *Pinus densiflora* and *Quercus variabilis* is under competitive relation with OAV in this site showed 1.01mm/year and 1.28mm/year, respectively. This result imply that OAV and other species including *P. densiflora* and *Q. variabilis* could influence negatively on the growth and survival of OAV in this site.

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LITERATURE CITED

Bormann, F.H. and Likens, G.E. 1979. Pattern and process in a forested ecosystem. Springer-Verlag, Berlin. 253p.

Bae, K.H. 1994. The study of forest community classification and major community dynamics in Mt. Kaya. Ph.D. Thesis, Kyungpook National Univ., Daegu. 135p. Braun-Blanquet, J. 1964. Pflanzensoziologie Grundzuge der Vegetation 3. Auf. Springer-Verlag. Wien. N.Y. 865p.

Escudero, A. 1996. Community patterns on exposed cliffs in a Mediterranean calcareous mountain. Vegetatio 125:99-110.

Table 1. Floristic composition of Arbor-vitae forests, Natural monument no. 1, Daegu city, Korea

Plot No.		1	2	3	4	5	6	7	8	9	10	
Site		D	D	E	C	E	C	A	B	B	A	
Height	(T1)	8	8	7.5	8	7.5	9	7.5	6	7	7	N.P.
	(T2)	5	3.5	5	3.5	3	4	3	3	3	3	
DBH	(T1)	15	10	9	9	9	14	11	13	15	15	
	(T2)	9	9	5	7	4	11	4	9	4	7	
Slope	(°)	40	45	25	50	45	45	85	60	80	90	
Aspect		NNW	-	NNW	NNW	-	-	NNW	-	-	-	-
Microtopography		US	US	R	MS	US	MS	LS	MS	MS	LS	
Exposed rock(%)		30	10	5	5	10	90	60	70	80	90	
No. of species occurred		33	24	25	21	26	11	5	26	19	7	
Quercus variabilis	T1	2.3	3.3	4.4	4.4	4.4	2.2		1.1			9
	T2			2.2	1.1	2.2			+	+		
	S			2.2		+			+			
	H	r	+	1.1	+	+	+		+		+	
Sedum kamtschaticum	H	+	+	+	+	+	+		+			7
Artemisia keiskeana	H	+		1.1	1.1	+						5
Q. serrata	T2		+									4
	S	+	+	1.1								
Platycarya strobilacea	T1	2.2	2.2	1.1		1.1						4
	T2	1.1		+		1.1						
	S			+								
Carex ciliato-marginata	H	+		1.1		1.1			+			4
Sorbus alnifolia	T2		+									3
	S		+	+		1.2						
Polygonatum odoratum var. *pluriflorum*	H	+	+			+						3
Thuja orientalis	T1	2.1	1.1					4.4	3.4	4.4	4.4	9
	T2		+		1.2		3.4	1.2	+	2.2	2.3	
	S				+	+	1.1	1.1	+	2.2	1.1	
Pyrrosia linearifolia	H							+		+	1.1	3
Bilderdykia dumetora	H		+						1.1	+	+	4
Cheilanthes argentea	H								r	+		2
Selaginella tamariscina	H	+	+	+	3.3	+	3.4	2.2	3.4	2.2	2.3	10
Pyrrosia petiolosa	H		+	+	+	+	+	+	+	+	+	9
Atractylodes japonica	H	+	+	1.1	+	1.1			+	r		7
Lactuca raddeana	H				+	+	+		+	+	+	6
Fraxinus rhynchophylla	T1	1.1			+					1.1		6
	T2	+	+									
	S									+		
	H		+			+			+	+		
Lindera obtusiloba	S	+	+		+	+			+	+		6
	H	+				+						
Indigofera kirilowii	S			+						+		5
	H				+	+			+			
Spodiopogon sibiricus	H			2.2	1.1		1.1		+			4
Callicarpa japonica	S	2.2	3.3						+	1.2		4
Carex ciliato-marginata	H	+		1.1		1.1			+			4
Q. mongolica	T2					+						3
	S				+							
	H			+								
Camptosorums sibiricus	H	+							+	+		3
Veronica dahurica	H			+		+			r			3
Q. dentata	T1				1.1							3
	T2				+							
	S			+	+	+						
Chrysnathemum zawadskii	H			+	+							3

<Table 1; continued>

Plot no.		1	2	3	4	5	6	7	8	9	10	
Lespedeza bicolor	S	+	+							+		3
Onicera praeflorens	S		1.1							+	1.1	3
Oplismenus undulatifolius	H		1.1							+	+	3
Securinega suffruticosa	S								+	+		2
Carex lanceolata	H	+			+							2
Davallia mariesii	H								+	+		2
Melampyrum roseum	H			1.2		1.2						2
Metaplexis japonica	H		+				+					2
Carex humilis	H	+					+					2
Potentilla freyniana	H	+		+								2
Melica onoei	H					+			+			2
Clematis mandshurica	H			+	r							2
Dryopteris bissetiana	H	+	1.1									2
Physocarpus instermedius	S	1.1				+						2
Rhododendron mucronulatum	S			1.1		+						2
Pueraria thunbergiana	H	+					+					2
Pinus densiflora	T1			1.1								1
Vitis thunbergii var. *sinuata*	H					+						1
Lysimachia barystachys	H					+						1
Viburnum dilatatum	S	+										1
Chrysnathemum boreale	H								+			1
Liriope spicata	H	+										1
Ampelopsis brevipedunculata var. *heterophylla*	H										+	1
Youngia denticulata	H			+								1
Securinega suffruticosa	H		+									1
Viola orientalis	H						+					1
Ulmus davidiana	T2		+									1
Zelkova serrata	S	+										1
Cocculus triobus	H				+							1
Rosa wichuraiana	H				+							1
Gynostemma pentaphyllum	H		+									1
Viola collina	H	+										1
Mosla punctulata	H	+										1
Deutzia coreana	S	+										1
Vitis amurensis	T2	+										1
Bidens frondosa	H							+				1
Rhus chinensis	S				+							1
Carex spp.	H			+								1
Euonymus oxyphyllus	T2					+						1
Viola verecunda	H	r										1
Isodon inflexus	H					+						1
Celtis aurantiaca	T2		1.1									1
Andropogon brevifolius	H			+								1
Calamagrostis arundinacea	H								+			1
Lepisorus thunbergianus	H	+										1
Albizzia julibrissin	S			+								1
Arthraxon hispidus	H	+										1
Rhamnus davurica	T2	1.1										1
Clematis patens	H	r										1
Phryma leptostachya var. *asiatica*	H		+									1
Lilium distichum	H		r									1

Note. T1: tree layer, T2 subtree layer, S shrub layer, H: herb layer, DBH: diameter of breast height, N.P. No. of Plots

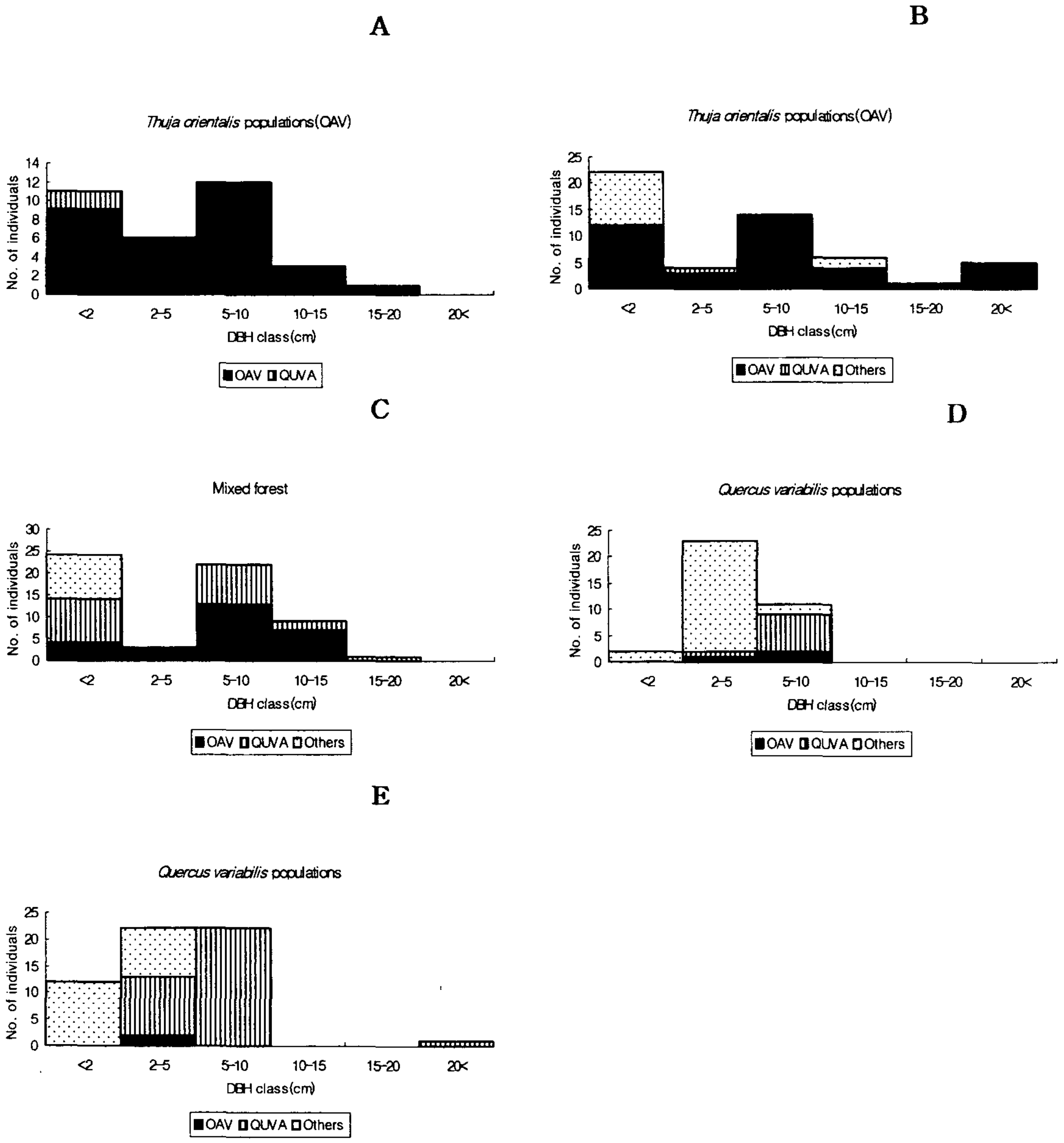
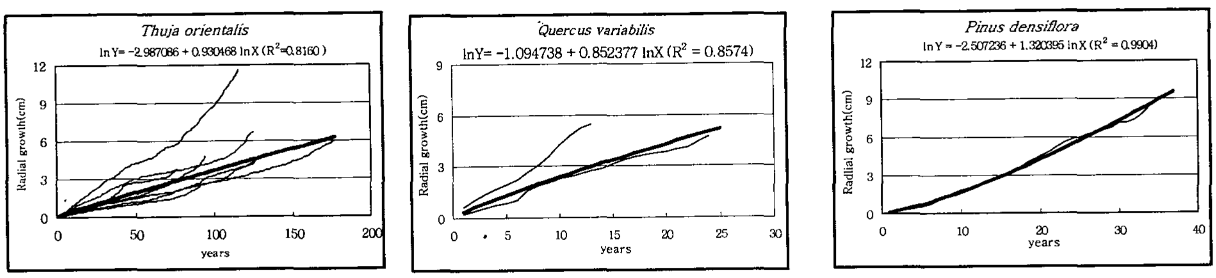


Fig. 3. Frequency distribution diagram of DBH classes of major tree species including OAV in the representative plots.



A B C

Fig. 4. Predicted and observed cumulative radial growth curves of annual ring widths (bold line: regression line).

Forcier, L.K. 1973. Seedling pattern and population dynamics, and the reproductive strategies of sugar maple, beech and yellow birch at Hubbard Brook. Ph.D. Thesis, Yale University.

Halle, F., Oldeman, R.A.A. and Tomlinson, P.B. 1978. Tropical trees and forests - An architectural analysis -. Springer-Verlag, Berlin. 441 p.

Harper, J.L. 1977. Population biology of plants. Academic Press, London. 892 p.

Hepburn, I. 1943. A study of the vegetation of sea-cliffs in north Cornwall. J. of Ecology 31:30-39.

Horn, H.S. 1975. Forest succession. Sci. Am. 232(5):90-98.

Jackson, G., and Sheldon, J. 1949. The vegetation of magnesian limestone cliffs at Markland Grips near Sheffield. J. of Ecology 37:38-50.

Kira, T. 1948. On the altitudinal arrangement of climatic zones in Japan. A contribution to the rational land utilization in cool highlands. Kanti-Nogaku 2:143-173(In Japanese).

Korea Meterological Administration(KMA). 1990-2000. Annual climatological report. Korea Meterological Administration, Seoul. (In Korean).

Lee C.B. 1985. Illustrated flora of Korea. Hyangmoonsa, Seoul. 310 p. (In Korean).

Marks, P.L. 1974. The role of pin cherry(*Prunus pensylvanica* L.) in the maintenance of stability in the northern hardwood ecosystem. Ecol. Mongr. 44:73-88.

Muller-Dombois, D. and H. Ellenberg. 1974. Aims and methods of vegetation ecology. New York. 547 p.

Okitsu, S., Ito, K. & Li, C. 1995. Establishment processes and regeneration patterns of montane virgin coniferous forest in northeastern China. J. Veg. Sci. 6:305-308.

Oliver,C.D. 1981. Forest development in North America following major disturbances. For. Ecol. Manage. 3:153-168.

Wilson, J.B., and Cullen, C. 1986. Coastal cliff vegetation of the Catlins region Otago, South Island, New Zealand. New Zealand Journal of Botany 24:567-574.

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