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Community Structure, and Size and Age Distribution of Conifers in Subalpine Korean Fir (*Abies koreana*) Forest in Mt. Chiri*

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지리산 아고산대 구상나무림의 군집구조 및 침엽수의 직경과 연령분포*

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ABSTRACT

Community structure, size and age distribution of tree species of the subalpine Korean fir (*Abies koreana*) forest at the elevation of 1,400~1,700m were studied in the north-west side of Chonwangbong Peak (1915m) in Mt. Chiri for the purpose of better understanding of the population dynamics of *Abies koreana*. Eight 20m X 20m permanent quadrats were established in 1991, and trees ≥ 2.5cm DBH for all species were marked with numbered aluminum tag, and saplings of Korean fir and Korean pine (*Pinus koraiensis*) were also tagged with aluminum sheet. These two conifer species comprised more than 60% of the total density and total basal area of the community. *Quercus mongolica* and *Acer pseudo-sieboldianum* were subdominants. Ordination study showed that cool temperate species such as *Sorbus commixta*, *Betula costata*, *Acer tschonoskii* and *Acer ukurunduense* occurred in close association with *Abies koreana* and *Pinus koraiensis*. Major tree species, especially *Abies koreana* and *Pinus koraiensis*, were well represented in smaller size classes, indicating that they were regenerating well. Age distribution of the *Abies koreana* and *Pinus koraiensis* showed that the former had longer physiological longevity than the latter, and that establishment were episodic and varied with sites, which implies the importance of the role of natural and artificial disturbances in this *Abies koreana* forest.

Key words: *Abies koreana*, Age distribution, Mt. Chiri, Ordination, *Pinus koraiensis*, Size-frequency distribution

INTRODUCTION

High altitude coniferous forests are subjected to frequent disturbances such as fire,

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drought, and insect outbreak in addition to direct human interference (Osawa 1988, Veblen 1986, Veblen *et al.* 1991, White *et al.* 1985). In recent years, indirect anthropogenic disturbances such as acid precipitation show significant adverse effects on these forests (Ashmore *et al.* 1985, Graumlich 1991, Klein *et al.* 1991, Van Deusen 1987). For these reasons, subalpine coniferous forests have received much attention in terms of the structure and dynamics of the community (Kang 1984, Kanzaki 1984, Kanzaki and Yoda 1986).

In south Korea, most natural forested areas are covered with deciduous hardwood forests, i.e. warm temperate and cool temperate deciduous forests (Yim 1977). However, in high elevation mountains, firs, spruces, and pines are dominating over the deciduous trees. In Mt. Chiri National Park, coniferous trees such as *Abies koreana*(Korean fir), *Abies holophylla, Pinus koraiensis*(Korean pine), and *Picea jezoensis* occur at the elevation >1,300 or 1,400m (Kang 1984). Anecdotally, high elevation coniferous forests in Mt. Chiri have been subjected to big fires. Selective cutting for timber harvest and clearcutting for the purpose of military strategy were also performed in Mt. Chiri in 1950's and 1960's. These natural and artificial disturbances have certainly affected the dynamics of this conifer community.

The purpose of this study is (1) to examine the community structure, and (2) to determine the size and age distribution patterns of major tree species of the *Abies koreana* community, in order to understand the population dynamics of *Abies koreana*, the dominant species on high elevation northern slopes near Jesokbong in Mt. Chiri.

STUDY SITE

This study was conducted near Jesokbong and Jangtomok (127°43′E and 35°20′N) on the north side of the main ridge of the mountains in the Mt. Chiri National Park. The elevation of the study site ranged from 1,400m to 1,700m. This area had been selectively cut during 1960's as an illegal timber harvert of *Abies koreana*, and many of the stumps have been left scattered all over the places.

Quadrat 1 was located at 1,700m elevation on a rocky slope with poor soil formation. Quadrat 7 and 8 were located on a small valley with large rocks, with many trees growing on the rock surface. Quadrat 4 was also located on a rocky slope. The other four quadrats were in better condition in terms of water stress but still contained some area with large rocks. All the quadrats were facing north or north-east (Fig. 1).

The weather in the study site is continental: mean annual temperature is 12.2 ℃ with the lowest in January (−1.8 ℃) and the highest in August (25.5 ℃), and the mean annual precipitation is 1341mm with the lowest in January and the highest in July for the periods 1961-1990 based on the data of Namwon Weather Observation Station, about 25km north-west of the study site (Korea Meterological Adminiatration 1991).

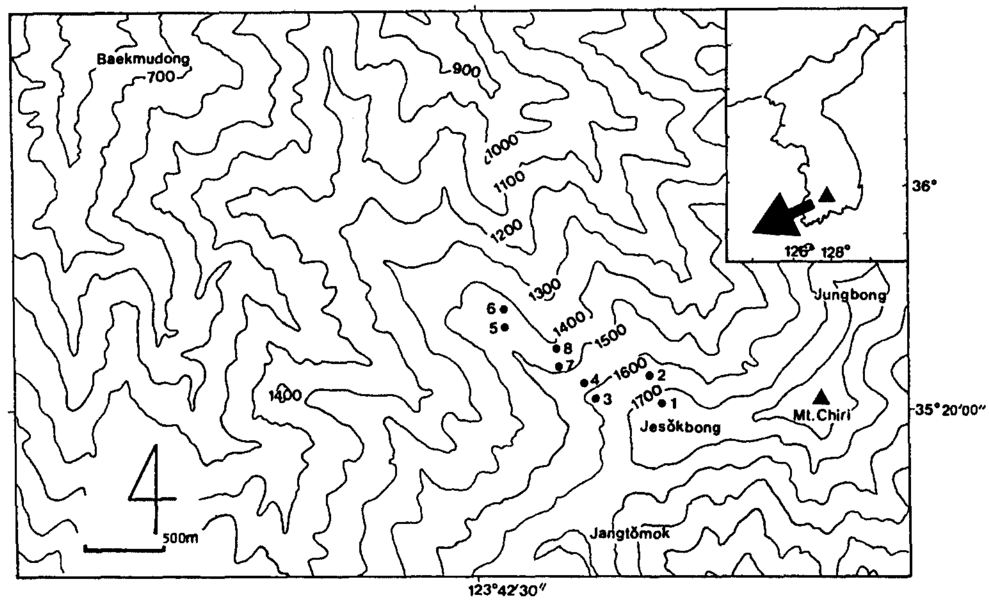

Fig. 1. Map of study sites in Mt. Chiri. Closed circles with numbers 1~8 indicate locations of permanent quadrats (20m×20m).

MATERIALS AND METHODS

Establishment of quadrats

In September 1991, eight permanent 20m × 20m quadrats were established on the north-west side of Mt. Chiri (Chonwangbong, 1915m). Location of the quadrats was subjectively selected to contain higher percentage of conifer species and for easier identification of the site for future visit. All the trees with DBH (diameter at breast height) ≥ 2.5cm were measured for DBH and identified to species. All trees were marked with numbered round aluminum tag (3.2cm in diameter) and aluminum nail. The importance value was calculated as the mean of relative density, relative basal area and relative frequency.

In each quadrat, one 5m × 20m subquadrat was established to examine the sapling growth and mortality of two major conifer species (*Abies koreana* and *Pinus koraiensis*). All the saplings (basal diameter ≥ 1cm and DBH< 2.5cm) were numbered with rectangular aluminum tag (9.2cm × 1.9cm).

Tree Coring

Two cores were extracted from each tree with DBH ≥ 10cm for the two conifer species (*Abies koreana* and *Pinus koraiensis*) with increment borer at 50cm height from the ground. Holes of the trees made by boring were disinfected with fungicide and plugged with wood putty in order to protect the tree from future infection by fungi. Cores were taken to the laboratory, air-dried, mounted on the wood core holder with Elmer's glue, sanded, and the rings were counted.

RESULTS AND DISCUSSION

Community structure

The forest on the northern slope near the main ridges of the Mt. Chiri was dominated by two conifers: *Abies koreana* (Korean fir) and *Pinus koraiensis* (Korean pine) (Table 1). These two species comprised about 60% of the tree density and 2/3 of the total basal area. Subdominant species of the community were *Quercus mongolica, Acer pseudo-sieboldianum* and *Fraxinus mandshurica*. *Q. mongolica* was not frequent in the quadrats studied, but the oak trees were in large diameter classes, showing high coverage values. *Fraxinus mandshurica* usually grows on the mesic site, near the valleys, while *Acer pseudo-sieboldianum* is a shade-tolerant subcanopy tree and grows in association with many different species.

Table 1. Vegetation structure of the *Abies koreana* community in Mt. Chiri. Importance value (%) is the mean of relative density, relative basal area and relative frequency.

Acronym	Species	Density (Trees/ha)	Basal Area (cm^2/ha)	Frequency	Importance Value (%)
ABKO	*Abies koreana*	492.9	23901	1.00	38.8
PIKO	*Pinus koraiensis*	114.3	35525	1.00	10.2
QUMO	*Quercus mongolica*	21.4	60732	0.29	6.6
ACPS	*Acer pseudo-sieboldianum*	92.9	10386	0.71	6.5
FRMA	*Fraxinus mandshurica*	71.4	11379	0.86	6.4
SOCO	*Sorbus commixta*	53.6	10946	0.57	4.7
BECO	*Betula costata*	28.6	18314	0.57	4.5
ACTS	*Acer tschonoskii*	39.3	4343	0.71	4.3
ACUK	*Acer ukurunduense*	39.3	3657	0.71	4.2
MASI	*Magnolia sieboldiana*	25.0	1800	0.71	3.6
PRLE	*Prunus leveilleana*	7.1	9232	0.29	2.0
FRRH	*Fraxinus rhynchophylla*	10.7	6242	0.14	1.4
SYRE	*Syringa reticulata*	7.1	407	0.14	0.8
TIAM	*Tilia amurensis*	3.6	1293	0.14	0.7
COCO	*Cornus controversa*	3.6	304	0.14	0.7
RHDA	*Rhamnus davurica*	3.6	175	0.14	0.7
STKO	*Stewartia koreana*	3.6	146	0.14	0.7
ACGI	*Acer ginnala*	3.6	139	0.14	0.7
SYCH	*Symplocos chinensis* for. *pilosa*	3.6	139	0.14	0.7
RHSC	*Rhododendron schlippenbachii*	3.6	118	0.14	0.7
EUMA	*Euonymus macroptera*	3.6	68	0.14	0.6
EUOX	*Euonymus oxyphyllus*	3.6	61	0.14	0.6
	TOTAL	1035.7	414418	8.96	100.0

This community has typical species of cool-temperate forest such as *Sorbus commixta, Betula costata, Acer tschonoskii* and *Acer ukurunduense* (Yim 1977). Theses pecies frequently occur with conifers in high elevation mountains in south Korea. Other minor species occurring in the quadrats such as *Magnolia sieboldiana, Syringa reticulata,* and *Cornus controversa* are shade-tolerant subcanopy trees.

Therefore this *Abies koreana* community on the north and noth-east facing slopes and valleys on high elevation areas in Mt. Chiri were mainly composed of northern components such as *Abies koreana, Pinus koraiensis, Sorbus commixta, Betula costata, Acer tschonoskii* and *Acer ukurunduense,* and contained shade-tolerant mesic subcanopy and canopy trees such as *Fraxinus mandshurica, Fraxinus rhynchophylla, Acer pseudo-sieboldianum,* and *Magnolia sieboldiana.*

Ordination study

The abundance and distribution of tree species are influenced by various environmental factors. One of the mathematical tools for examining the relationship between environmental factors and vegetation is ordination (Peet *et al.* 1988). Sample quadrats and species are arranged in the order of similarity in this method (Mueller-Dombois and Ellenberg 1974). In order to determine the relationships among species and among quadrats, DCA (Detrended Correspondence Analysis) ordination was performed (Hill 1979, Hill and Gauch 1980) using the data matrix of importance values for species in each quadrat in Mt. Chiri.

In the species ordination (Fig. 2), tree species which are common on disturbed sites receiving large amount of lights such as *Acer ginnala, Prunus leveilleana* and *Fraxinus rhynchophylla* were located on the upper part of axis one. In contrast, tree species common on cool-temperate high elevation region such as *Abies koreana, Pinus koraiensis, Sorbus commixta, Betula costata,* and *Acer tschonoskii* were located on the lower part of the axis

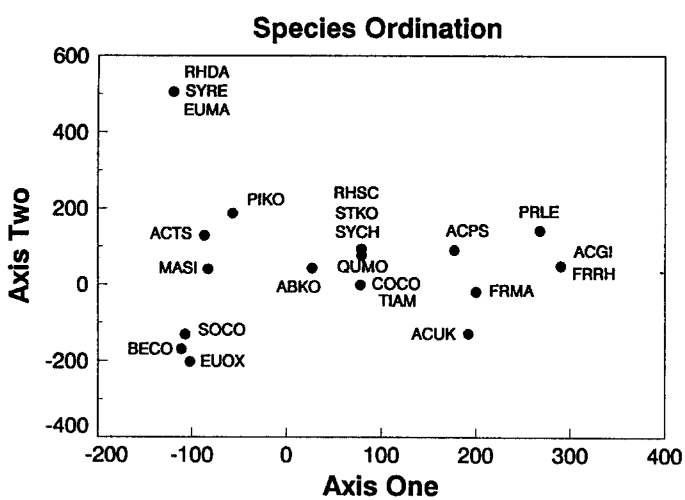

Fig. 2. DCA ordination diagram for 22 tree species occurring in the study site. See Table 1 for the species name of the acronym.

one. Axis one explained about 83% of the total variation of the distribution of tree species, and axis two explained about 15% of the variation.

In the sample ordination (Fig. 3), the sample quadrats were divided into two groups on the axis one: one with high proportion of *Abies koreana* and *Pinus koraiensis* on rocky slopes and valleys (Quadrats 2,4,7,8), and another with relatively higher percentages of rare species and non-conifers (Quadrats 3,5,6). In Quadrat 6, vines and shade-intolerant trees were abundant indicating that a relatively large disturbance occurred recently.

These results of ordination implies the close association of *Abies koreana* and *Pinus koraiensis* with cool temperate deciduous hardwood species such as *Sorbus commixta, Betula costata,* and *Acer tschonoskii* on high elevation mountain areas in south Korea (Yim 1977). However, this association can vary slightly among different places (Kim *et al.* 1991).

Size-frequency distribution of major tree species

Size-frequency distributions are very useful in assessing the pattern and status of regeneration (Lorimer and Krug 1983, Seischab 1986). Shade-tolerant trees are typically very abundant in the understory while shade-intolerant trees are not successful in the understory as long as the forest canopy is intact (Canham and Marks 1985). The size-frequency distributions of the most abundant tree species in this study showed reverse J-shaped curves when the smallest size class (DBH $\geq$ 2.5cm and $<$ 5.0cm) was not considered (Fig. 4). Especially, *Abies koreana* and *Acer* spp. were well represented by the smaller size classes.

When seedlings (basal diameter $<$ 1.0cm) and saplings (basal diameter $\geq$ 1.0cm and DBH $<$ 2.5cm) are included in the smallest size class, this class showed the highest numbers. The numbers of seedlings and saplings of *Abies koreana* were 657 and 1,743

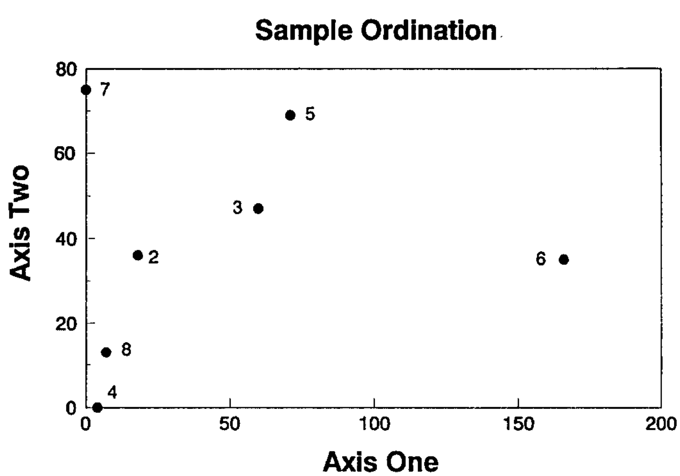

Fig. 3. DCA ordination diagram for sample quadrats in the study site. See Fig. 1 for the location of quadrats.

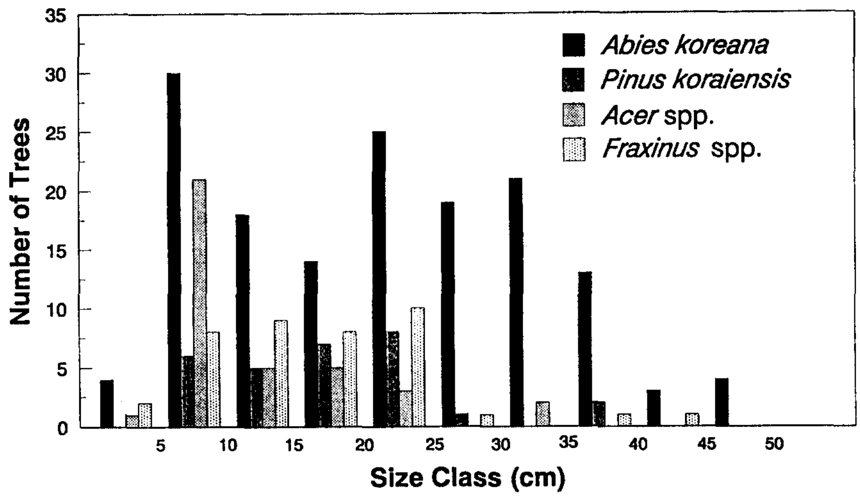

Fig. 4. Size-frequency distribution of major tree species in the study site. *Acer* spp. includes *A. pseudo-sieboldianum, A. tschonoskii, A. ukurunduense* and *A. ginnala*, and *Fraxinus* spp. includes *F. mandshurica* and *F. rhynchophylla*. Numbers of trees are based on the 7 sample quadrats (0.28ha). The smallest size class includes only trees with DBH ≥ 2.5cm and < 5cm.

individuals/ha, respectively, and those of *Pinus koraiensis* were 157 and 371 individuals/ha, respectively. Therefore, it can be concluded that the major tree species in the *Abies koreana* community are regenerating well. *Quercus mongolica*, although not included in Fig. 1, was the only species with higher number of individuals in the upper size classes, which is typical for shade-intolerant species (Boerner and Cho 1987, Cho and Boerner 1991). With many seedlings, saplings, and pole-sized trees (usually DBH < 10cm), the two conifer species, *Abies koreana* and *Pinus koraiensis*, seems to be self-regenerating well under the current disturbance regime, although the abundance of seedlings and saplings vary significantly from site to site.

Age distribution

Tree age was determined by examining cores extracted from trees ≥ 10cm in DBH for the two conifer species, *Abies koreana* and *Pinus koraiensis*. Overall, the two species showed a bell-shaped curve (Fig. 5). The oldest tree cored was about 300 year-old (at 50cm height) *Abies koreana*, and because large trees frequently had rotten trunks, there might be more *Abies koreana* trees around 300 years old. The physiological longevity of *Pinus koraiensis* seems shorter than that of *Abies koreana*; the oldest *Pinus koraiensis* tree in the study site was about 200 years old.

Although the ages of trees as a whole were more or less evenly distributed over the years, the establishment years were episodic in each quadrat. For example, about 40% of the *Abies koreana* in Quadrat 8 were established in late 1860's and early 1870's, and two episodes of establishement, one in early 1900's and another in late 1910's, occurred in Quadrat

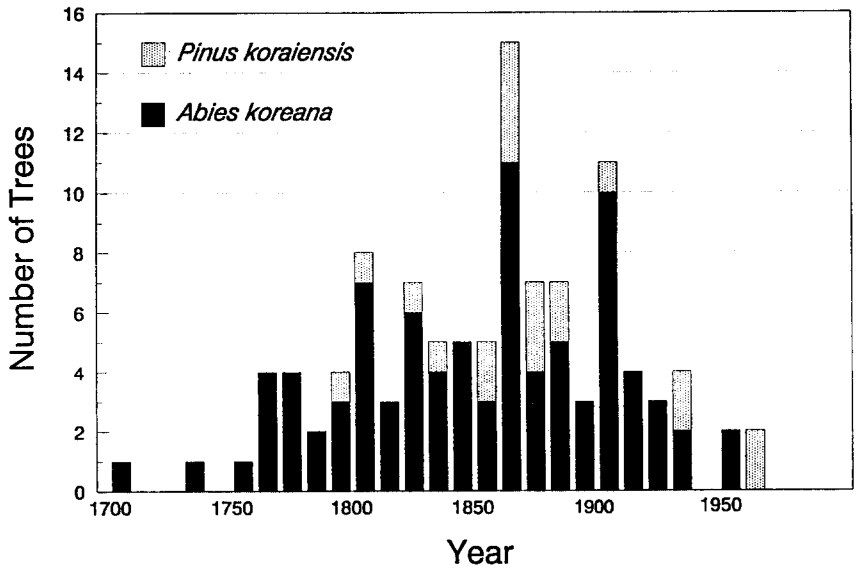

Fig. 5. Age (age at 50 cm height) distribution of *Abies koreana* and *Pinus koraiensis* in Mt. Chiri. X-axis indicates the year of establishment. Numbers of trees are based on the 8 sample quadrats (0.32ha). Trees with DBH < 10cm were excluded.

3. It seems that these two conifer species rely on some kind of disturbance which opens up a canopy gap for their establishment (Boerner *et al.* 1988, Foster and Reiners 1983, Nicholas *et al.* 1992). However, large scale disturbances may interfere with the regeneration of conifers because vines and shrubs on the ground floor obstruct the passage of sunlight (Pauley and Clebsch 1990). The establishment patterns in each quadrat in relation to small scale disturbances such as selective cutting will be examined later from the growth of annual rings of trees.

An examination of size and age revealed that tree size may be a better indicator of the performance of trees than tree age. Some trees growing on the rock were twice as old as trees on the deep organic soil even though they had the same DBH. Overall, the establishemnt patterns of *Abies koreana* and *Pinus koraiensis* from size and age distribution showed that they are not in decline now, and that they seemed to be regenerating well. However, the exact status and future performance of *Abies koreana* will be determined using the Leslie matrix model based on the data of seedling establishment, growth and survival of saplings, and growth and mortality of trees in the permanent quadrats.

적 요

구상나무(*Abies koreana*)의 개체군동태를 잘 이해하기 위한 목적으로 지리산의 제석봉과 장터목 북사면의 고도 1,400~1,700m의 구상나무림에서 군집구조 및 주요구성수종의 직경계급과 연령의 분포를 조사하였다. 1991년에 8개의 20m × 20m 영구방형구를 설치하여 흉고직경 2.5cm

이상의 모든 종의 수목에 대하여 알루미늄 번호표를 부착하였고 구상나무와 잣나무(*Pinus koraiensis*)의 치수(기저직경 1.0cm 이상, 흉고직경 2.5cm 미만)에 대하여도 알루미늄 꼬리표를 부착하였다. 이들 두 종의 침엽수는 이 군집의 전체 밀도와 전체 기저면적의 60% 이상을 차지하였다. 신갈나무(*Quercus mongolica*)와 당단풍(*Acer pseudo-sieboldianum*)은 아우점종으로 나타났다. DCA ordination을 수행한 결과 냉온대 수종인 마가목(*Sorbus commixta*), 사스레나무(*Betula costata*), 시닥나무(*Acer tschonoskii*) 및 부게꽃나무(*Acer unkundense*)는 구상나무와 잣나무와 함께 출현하는 것으로 나타났다. 특히 구상나무와 잣나무와 같은 구상나무림의 주요수종들은 작은 직경의 개체들이 많아 재생이 활발히 일어나는 것으로 생각된다. 구상나무와 잣나무의 연령분포를 보면 구상나무가 잣나무보다 생리적 수명이 더 긴 것으로 판단되며 이들 두 침엽수의 정착은 간헐적이고 장소에 따라 달라서 이 구상나무군집에서의 자연적이거나 인위적인 교란은 이들 두 침엽수종의 정착에 중요한 역할을 맡고 있음을 시사하고 있다.

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