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Actual Vegetation and Potential Natural Vegetation of Pukhansan National Park, Mid-western Korea

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北漢山國立公園의 現存植生과 潛在自然植生

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ABSTRACT

The potential natural vegetation of the Pukhansan National Park area, mid-western Korea, was inferred from the actual vegetation. With the phytosociological classification and field surveys, the actual vegetation map of the park area was made on a scale of 1:25,000, including fourteen communities. By the analyses of the species diversity, the age structure, the human interferences and various informations on vegetation changes, two pathways of late stage succession from *Pinus densiflora* forests to the climatic climax were suggested. One is from *Quercus serrata* forests to *Q. mongolica* forests throughout the mountain and the other, from *Q. variabilis* or *Q. acutissima* forests to *Carpinus laxiflora* forests in lower parts. Considering the vegetation changes, the potential natural vegetation of the park area mainly composed of *Q. mongolica*, *C. laxiflora*, *P. densiflora* and *Zelkova serrata* forest as the climatic and/or edaphic climax was inferred.

Key words: Actual vegetation, Age structure, Climax, Potential natural vegetation, Species diversity, Succession, Vegetation change, Vegetation map.

INTRODUCTION

Actual vegetation is vegetation which actually exists at the time of observation, regardless of the character, condition, and stability of its component communities (Küchler 1967). Plant species are the building blocks of the plant communities that together constitute the vegetation of different regions (Walter 1979). Present ranges of the species and community distribution, however, do not indicate their natural ranges. Today it is intimately linked with the history of the region and the result of a long development in the plant and animal world, including even human life. As a result, we can never afford to neglect the historical factors of plant species and plant communities to realize the actual vegetation.

Potential natural vegetation is theoretical vegetation which will form in the future when human activities such as ploughing, cultivating, mowing, fertilizing, burning, irrigating, draining, grazing and planting native and introduced species are ceased (Suzuki *et al.* 1979). In order to obtain the potential natural vegetation, two assumptions are necessary: (1) that man be removed from the scene, and (2) that the resulting succession of plant communities be telescoped into a single moment in order to exclude the effects of climatic changes. In the potential natural vegetation of today, man's past activities may remain a factor. It is essentially the same as the climax vegetation, provided the term 'climax' is not used in the original Clementsian sense but rather in the modern and more realistic way (Küchler 1967). Therefore, the potential natural vegetation can be inferred considering the actual vegetation, the climatic characteristics and succession, and the dynamics of plant communities etc. (Stumpel and Kalkhovan 1978, Brush *et al.* 1980, Babalonas 1980, Abbort 1981, Schroeder 1983).

In Korea some reviews of actual vegetation and potential natural vegetation were found (Yim and Baik 1985, Kim and Yim 1987, 1988a, Yim *et al.* 1990, Yim and Kim 1992), but not that of the Pukhansan National Park area. To discern the actual vegetation and potential natural vegetation, analyses on the species distribution range, age structures of plant communities, behaviors of different species and the species diversity within plant communities in relation to abiotic environmental factors were carried out.

SITE DESCRIPTION

The Pukhansan National Park area (ca. 78.5 km²) is located in ranges of 37°35′53″~37°43′54″ N and 126°56′05″~127°03′04″ E. The park is largely covered with oak forests. Pine forests are found in scattered in such poor habitats as hillocks, exposed ridges and rocky steep ascents. Oak forests have been recognized as distinct forest vegetation in the cool-temperate zone of Korea. Of them the mongolian oak (*Quercus mongolica*) is the character species in the northern part of the cool-temperate zone (Uyeki 1933, Yim 1977). The mongolian oak is widely distributed throughout the southeastern Siberia, the Mongolia, the Manchuria and the Korean peninsula (Kim 1992).

The meteorological data of Seoul for our discussion are referred to as follows : The annual mean temperature 11.6℃, the mean annual precipitation 1,365 mm and the Thornthwaite's moisture index 74.0 (Yim and Kira 1976) are reffered to the discussions.

MATERIALS AND METHODS

Vegetation survey

By the Zürich-Montpellier school method (Braun-Blanquet 1964), 64 sites were selected. According to the concept of minimal area (Kim *et al.* 1995), 100 m²~400 m² size quadrats were randomly set at the relevés (Fig. 1). The dominance, sociability, diameter at breath height (dbh), the height and number of vascular plant species and habitat conditions such as altitude, slope aspect, slope degree, direction and po-

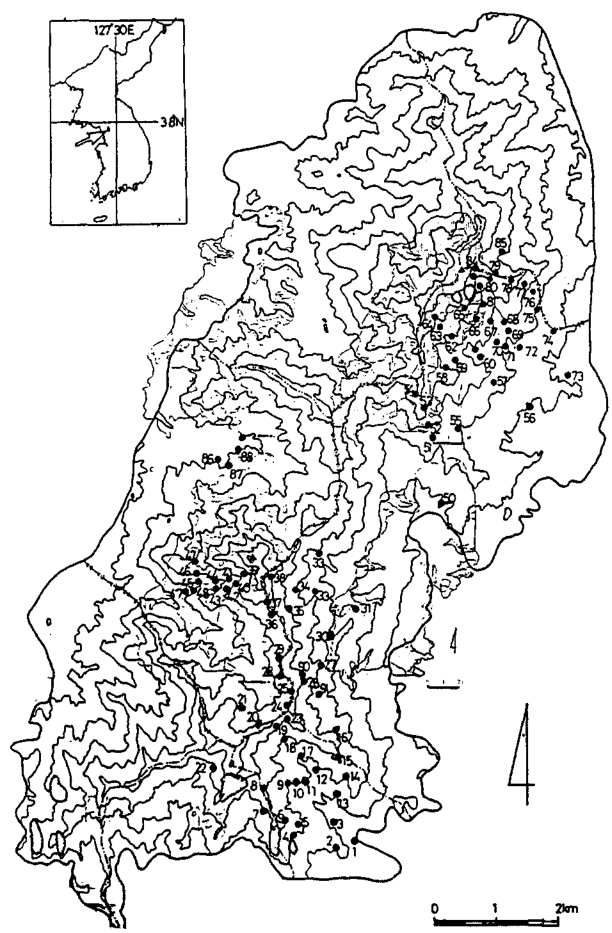


Fig. 1. Map showing the sampling sites selected in Pukhansan National Park area. Figures at closed circles indicate relevé numbers.

wer of wind, moisture and texture of soil and sunlight in each relevé were described (Werger 1974, Miyawaki *et al.* 1981). The plant names were recorded according to Lee (1979).

Classification of vegetation

Using the tabular comparison method (Shimwell 1971, Mueller-Dombois and Ellenberg 1974) plant communities were classified and documented in structured tables. The constancy of a species was determined by calculating the proportion of the number of relevés per structured table to the total numbers of relevés for a given community. The species of constancy class I and those having a negligible discriminative value are disregarded in the final presentation (Table 1). The vegetation units of the forest in the park area were compared with those of other regions (Kim and Yim 1986, 1988a, Yim and Kim 1992, Kim 1992, Song *et al.* 1995, Kil and Kim 1996).

Age structure and species diversity analyses

For detection of the behaviors of plant species in the population and community level, the species diversity and community structure, especially the dbh class-frequency (Kim 1977) were analyzed with the data base obtained. The trees over 2 cm in dbh in different plant communities were censused for age structure analyses and the determination of the successional stage (Kim and Yim 1987, 1988b, Yim and Kim 1992). The species diversity (H') of the fourteen communities by phytosociological classification was calculated by $H' = -\Sigma\, pi \log_2 pi$(Shannon and Weaver 1963), where, pi is the relative abundance of species i.

Vegetation mapping

The actual vegetation map of the park area was made on a scale of 1:25,000 based on the results of phytosociological classification, ordinations and field surveys. The potential natural vegetation map of the park area was made on a scale of 1:25,000 considering the analyses of actual vegetation, physical conditions limiting vegetation distribution and informations on the vegetation changes including human impacts.

RESULTS AND DISCUSSION

Floral characteristics and species distribution

The distributions of 649 vascular plant species were listed in the Pukhansan National Park area. The present record differs from those of 30 years ago. The number of species listed is 58 less than 707 species from the past surveys (Lee 1957, Chung and Lee 1962). Of them 125 species are newly recorded and 183 species living in wet habitats are not yet confirmed. It seems that mesic sites of the park area such as marsh and ravine were destroyed by human interferences.

Of the vascular plants listed, *Quercus mongolica*, *Pinus densiflora*, *Acer pseudo-sieboldianum*, *Rhododendron schlippenbachii*, *R. mucronulatum* and *Stephanandra incisa* are wide-spread species, on the other hand *Zelkova serrata*, *Carpinus laxiflora*, *Acer mono* and *Sasa borealis* are rarely found. *Q. mongolica* and *P. densiflora* occur throughout the mountain, *Q. serrata* below 600m in altitude of the slopes, *Q. variabilis* below 200m, *Q. acutissima* on the lower slopes or around the villages of the mountain area and *Robinia pseudoacacia* on the slopes disturbed(Fig. 2).

Plant communities

The forest of the Pukhansan National Park area was classified into nine communities and five plantations:

***Acer pseudo-sieboldianum* - *Quercus mongolica* community(Table 1-1)**

Quercus mongolica, *Disporum smilacinum*, *Carex siderosticta*, *C. ciliato-marginata*, *Tripterygium regelii*, *Ainsliaea acerifolia*, *Athyrium nipponicum*, *Astilbe*

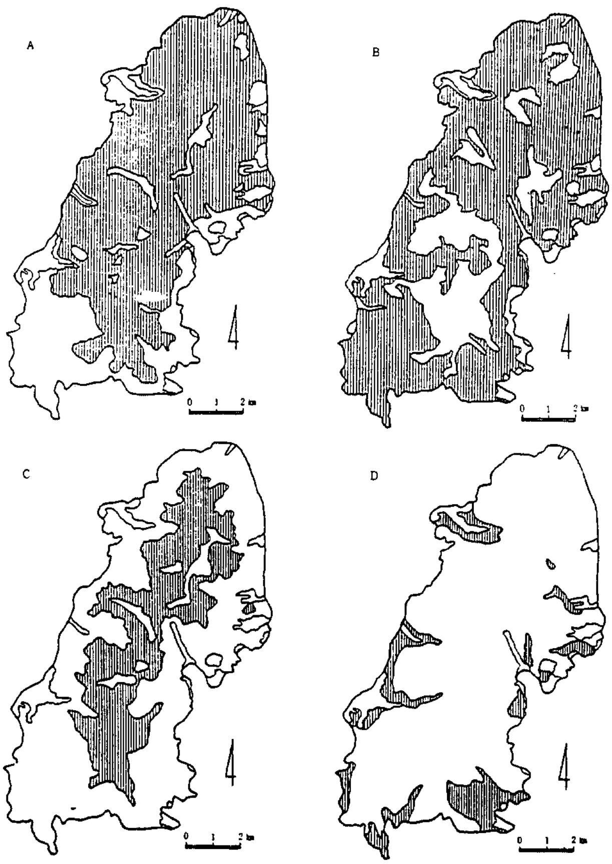


Fig. 2. Map showing the distribution of four important species, *Quercus mongolica*(A), *Pinus densiflora*(B), *Acer pseudo-sieboldianum*(C) and *Robinia pseudoacacia*(D), living in Pukhansan National Park area.

chinensis var. *davidii*, *Veratrum japonicum*, *Saussurea seoulensis*, *Asarum sieboldii* var. *seoulensis*, *Acer pseudo-sieboldianum*, *Polygonatum humile*, *Asperula odorata*, *Magnolia sieboldii* and *Heloniopsis orientalis* are character species. These species occur on xeric sites such as upper parts of the slopes and ridge lines. The preserved forests of the community are formed with the trees of dbh 30 cm and the forest coverage 80%. The forest stands may distribute above 450 m in altitude, 20°~30° in slope degree and NW~SE in slope aspect. The *Acer pseudo -sieboldianum* - *Quercus mongolica* community includes two subunits, typical subcommunity and *Euonymus oxyphyllus* subcommunity(Table 1-1).

a: *Euonymus oxyphyllus* subcommunity: This subcommunity is distinguished from other by *Euonymus oxyphyllus*, *Clematis mandshurica*, *Discorea quinqueloba*, *Viola albida* and *Cynanchum atratum*, character species. The forests are occurred on NE~SE in slope aspect.

b: Typical subcommunity: This is a typical subcommunity of *Acer pseudo-sieboldianum* - *Quercus mongolica* community. The forests are usually occurred on NW~W in slope aspect.

Quercus mongolica community(Table 1-2)

The community is distinguished from *Acer pseudo -sieboldianum* - *Quercus mongolica* community by absense of *Asarum sieboldii* var. *seoulensis*, *Acer pseudo-sieboldianum*, *Polygonatum humile*, *Asperula odorata*, *Magnolia sieboldii* and *Heloniopsis orientalis*. This community occurs on more mesic sites than those of Acero-Quercetum mongolicae. The forests are formed with trees of dbh 25 cm~30 cm and canopy coverage of 75%. The forest stands may distribute on 250 m~450 m in altitude, 20°~30° in slope degree and NE in slope aspect. In the tree layer of the association *Sorbus alnifolia* and *Quercus serrata* are found as companion species with lower coverage. The shrub layer is dominated with *Rhododendron schlippenbachii*, *R. mucronulatum*, *Stephanandra incisa*, *Lindera obtusiloba*, *Symplocos chinensis* var. *pilosa*, *Rhus trichocarpa*, *Lespedeza maximowiczii*, *Viburnum erosum*, *Weigela florida* and *Callicarpa japonica* are rarely found. The herb species such as *Carex lanceolata*, *Viola rossii*, *Smilax nipponica*, *Artemisia keiskeana*, *Hemerocallis fulva*, *Atractylodes japonica* and *Viola orientalis* live in undergrowth.

Pinus densiflora - _Quercus mongolica_ community(Table 1-3)

This community is the mixed forest of *Quercus mongolica* and *Pinus densiflora*.

Quercus variabilis community(Table 1-4)

The community occurs more abundantly on the sunny steep mountainsides and xeric hillsides. The forest stands may distribute below 200m in altitude and S~SE in slope aspect. High constants are *Lespe-*

Table 1. The vegetation table of Pukhansan National Park. Roman figures indicate 20% constancy classes (Braun-Blanquet 1964)

1=*Acer pseudo-sieboldianum* - *Quercus mongolica* community: a=*Euonymus oxyphyllus* subcommunity, b=Typical subcommunity, 2=*Quercus mongolica* community, 3=*Pinus densiflora* · *Quercus mongolica* community, 4=*Quercus variabilis* community, 5=*Quercus acutissima* community, 6=*Robinia pseudoacacia* plantation, 7=*Alnus hirsuta* plantation, 8=*Alnus hirsuta* var. *microphylla* plantation, 9=*Pinus densiflora* community.

Column	1		2	3	4	5	6	7	8	9
	a	b								
Number of quadrats	15	17	6	7	4	5	3	3	2	2
Average number of species	41	34	40	31	24	31	26	33	22	16
Quercus mongolica	V	V	V	V	4	III	2	2	·	2
Disporum smilacinum	V	V	V	·	·	I	1	3	·	·
Carex siderosticta	IV	IV	IV	·	1	·	1	1	·	·
Carex ciliato-marginata	IV	III	III	·	1	·	1	2	·	·
Tripterygium regelii	IV	III	V	·	·	·	1	2	·	·
Ainsliaea acerifolia	III	III	V	·	·	·	1	1	1	·
Athyrium nipponicum	VI	III	III	I	·	I	·	1	1	·
Astilbe chinensis var. *davidii*	II	II	IV	·	·	I	·	1	1	·
Veratrum maackii var. *japonicum*	II	II	III	·	·	·	1	·	1	·
Saussurea seoulensis	III	II	II	I	·	·	·	·	·	·
Asarum sieboldii var. *seoulensis*	III	I	II	·	·	·	·	·	·	·
Acer pseudo-sieboldianum	V	V	·	I	·	I	·	2	1	·
Polygonatum humile	III	II	·	·	·	·	1	1	·	·
Asperula odorata	III	I	·	·	·	·	·	·	·	·
Magnolia sieboldii	II	I	·	·	·	·	·	·	·	·
Heloniopsis orientalis	II	I	I	·	·	·	·	·	·	·
Euonymus oxypyllus	II	·	·	·	·	·	·	·	·	·
Clematis mandshurica	II	·	I	·	·	·	·	·	·	·
Discorea quinqueloba	II	·	·	·	·	·	·	·	·	·
Viola albida	II	·	·	·	·	·	·	·	·	·
Cynanchum atratum	II	·	·	·	·	·	·	·	·	·
Pinus densiflora	·	I	I	III	2	I	·	3	·	2
Quercus variabilis	·	·	·	I	4	·	·	·	·	·
Quercus acutissima	·	·	·	I	1	V	·	·	·	·
Robinia pseudoacacia	·	·	·	I	3	II	3	1	·	1
Alnus hirsuta var. *sibirica*	·	I	I	·	2	I	·	3	·	1
Alnus hirsuta var. *microphylla*	·	·	·	·	·	·	·	·	2	·
Indigofera kirilowii	·	I	I	III	1	·	1	·	·	·
Smilax china	I	·	I	III	1	I	·	·	1	·
Quercus aliena	·	·	I	II	·	II	·	1	·	·
Cocculus trilobus	I	·	I	I	·	I	1	·	·	·
Miscanthus sinensis	·	I	·	III	1	·	1	·	·	·
Onoclea sensibilis var. *interrupta*	·	·	·	I	1	I	1	·	·	·
Yongia denticulata	·	·	·	II	1	·	·	2	·	·

Table 1. Continued

Column	1		2	3	4	5	6	7	8	9
	a	b								
Number of quadrats	15	17	6	7	4	5	3	3	2	2
Average number of species	41	34	40	31	24	31	26	33	22	16
Smilax sieboldii	I	I	I	II	1	I	3	1	·	·
Stellaria aquatica	·	·	·	·	·	·	·	·	2	·
Rhododendron mucronulatum	IV	V	V	V	4	IV	3	2	1	2
Carex lanceolata var. *nana*	IV	V	III	V	4	V	2	3	·	2
Stephanandra incisa	V	V	V	III	2	V	2	1	2	1
Rhododendron schlippenbachii	V	V	V	V	3	II	·	3	·	2
Lindera obtusiloba	V	V	IV	IV	2	III	1	2	2	·
Symplocos chinensis for. *pilosa*	V	IV	V	IV	2	IV	2	2	1	·
Spodiopogon cotulifer	III	IV	V	IV	3	IV	2	3	·	1
Artemisia keiskeana	IV	III	V	IV	4	III	·	2	·	1
Sorbus alnifolia	IV	IV	V	II	2	III	2	3	·	2
Rhus trichocarpa	IV	V	IV	III	1	II	1	2	1	·
Viola rossii	IV	IV	III	III	1	III	·	3	·	·
Smilax nipponica	V	III	IV	II	1	II	2	·	·	·
Lespedeza maximowiczii	III	III	III	III	·	III	·	·	1	·
Hemerocallis aurantiaca	V	III	IV	III	·	I	·	1	·	·
Atractylodes japonica	IV	III	III	II	1	III	·	·	·	·
Athyrium yokoscense	II	III	V	III	·	II	2	1	2	·
Prunus sargentii	II	III	I	IV	4	I	·	2	1	·
Juniperus rigida	II	II	II	IV	4	I	·	2	·	1
Viburnum erosum	III	III	III	II	1	III	1	·	·	·
Quercus serrata	I	II	III	III	2	IV	2	1	·	1
Lespedeza bicolor	I	II	III	III	3	III	·	·	·	2
Viola orientalis	III	III	III	·	·	I	1	1	·	·
Aster scaber	IV	III	II	II	1	I	·	·	·	·
Solidago virga-aurea var. *asiatica*	IV	II	I	·	·	III	·	1	1	·
Callicarpa japonica	II	I	III	II	·	I	1	3	1	1
Potentilla fragarioides var. *major*	III	II	I	II	·	III	1	·	·	·
Melampyrum roseum	II	II	I	IV	·	II	·	2	·	·
Rubus crataegifolius	II	II	I	II	·	II	2	2	·	·
Fraxinus rhynchophylla	III	II	II	I	·	III	·	1	·	·
Artemisia stolonifera	II	II	·	I	·	I	1	1	·	·
Lysimachia clethroides	III	II	I	II	·	II	1	·	·	·
Weigela subsessilis	I	II	II	III	·	I	1	3	1	1
Weigela florida	II	II	III	II	1	I	·	·	·	1
Parthenocissus tricuspidata	I	I	II	III	·	III	1	2	1	·
Pyrola japonica	III	I	I	I	1	I	·	·	·	·
Styrax obassia	II	II	·	I	1	·	·	1	·	·
Corylus heterophylla var. *thunbergii*	·	I	II	I	1	III	·	·	·	1
Alnus hirsuta	·	I	III	·	1	I	2	1	1	1
Euonymus alatus for. *ciliato-dentatus*	II	I	II	I	·	·	·	·	2	·
Polygonatum odoratum var. *pluriflorum*	II	I	II	·	·	·	2	1	·	·
Castanea crenata	I	I	·	I	2	I	1	1	·	·
Allium thunbergii	II	I	I	·	·	II	·	·	·	1
Ampelopsis brevipendunculata	I	I	II	I	2	I	·	·	·	·
Zanthoxylum schinifolium	I	I	·	I	·	I	2	1	·	·
Carex lanceolata	I	·	II	·	·	·	2	1	1	·
Festuca ovina	I	I	·	I	1	·	1	1	·	·

Table 1. Continued

Column	1		2	3	4	5	6	7	8	9
	a	b								
Number of quadrats	15	17	6	7	4	5	3	3	2	2
Average number of species	41	34	40	31	24	31	26	33	22	16
Convallaria keiskei	II	I	I	·	·	·	1	·	·	·
Euonymus sachalinensis	I	I	·	I	·	I	·	·	·	·
Pteridium aquilinum var. *japonicum*	I	·	II	II	·	·	·	·	1	·
Hemerocallis minor	·	I	II	I	·	·	·	·	·	1
Disporum viridescens	I	I	II	·	·	·	·	·	·	·
Smilax oldhami	I	I	I	·	·	·	·	·	·	·
Peucedanum terebintaceum	I	I	I	·	·	I	·	·	·	·
Aconitum uchiyamai	I	·	·	·	·	·	·	·	1	·
Cornus kousa	I	I	·	·	·	·	·	·	·	·
Clematis heracleifolia	I	·	·	·	·	·	·	·	1	·
Eupatorium chinensis var. *simplicifolium*	I	·	I	II	·	·	1	·	·	·
Celastrus orbiculatus	·	·	I	·	1	·	·	1	·	·
Viola variegata var. *nipponica*	I	·	·	I	·	·	·	·	·	·
Gentiana scabra var. *buergerii*	I	I	·	·	·	·	·	·	·	·
Clerodendron trichotomum	I	·	·	·	·	I	2	1	·	·
Isodon inflexus	I	·	I	·	·	·	·	·	·	·
Artemisia japonica	·	I	·	I	·	·	·	·	·	·
Securinega suffruticosa	·	I	·	I	·	·	1	·	·	·
Vaccinium koreanum	I	I	·	·	·	·	·	·	·	·
Angelica decursiva	·	I	·	I	1	·	·	·	·	·
Syneilesis palmata	I	I	I	·	·	·	·	·	·	·
Commelina communis	·	·	·	I	·	·	1	1	1	1
Lespedeza cyrtobotrya	I	·	·	I	1	·	·	·	·	·
Pinus rigida	·	·	·	·	·	I	1	1	·	·
Ostericum sieboldii	I	·	·	I	·	·	·	·	·	·
Rhododendron yedoense var. *poukhanense*	I	·	·	·	·	I	·	·	·	·
Isodon excisus	I	·	·	·	·	·	·	·	·	·
Veratrum paturum	·	I	I	·	·	·	1	·	·	·
Euonymus macroptera	I	I	·	I	·	·	·	·	·	·
Patrinia saniculaefolia	I	I	·	·	·	·	·	·	·	·
Maackia amurensis	I	·	·	I	·	·	·	·	·	·
Pimpinella brachycarpa	I	·	·	·	·	·	·	·	·	·
Iris nerschinskia	I	I	·	I	·	·	·	·	·	·
Artemisia sylvatica	·	I	·	·	·	I	·	1	·	·
Quercus dentata	I	·	·	I	1	·	·	·	·	·
Codonopsis lanceolata	I	·	·	·	·	·	·	·	·	·
Dryopteris crassirhizoma	I	·	I	·	·	I	·	·	·	·
Arundinella hirta	·	·	·	·	1	I	·	1	·	·

deza bicolor, *Indigofera kirilowi* and *Artemisia keiskeana* after pioneer species. This indicates that *Q. variabilis* forests develop secondarily when the forests are destroyed by some causes. The forests are regarded as a topographic or edaphic climax. In the upper tree layer of *Q. variabilis* forest of about 10m tall, 10 cm~20 cm in dbh and canopy coverage of 75%, *Q. mongolica*, *Prunus sargentii* and *Styrax obassia* are observed. The lower tree layer is usually rather open, where *Symplocos chinensis* for. *pilosa*, *Juniferus rigida*, *Callicarpa japonica*, etc. are sometimes scattered. The shrub layer covered with *Rhododendron mucronulatum*, *R. schlippenbachii* and *Stephanandra incisa* and the herb layer is dominated by several sedges.

***Quercus acutissima* community(Table 1-5)**

The community occurs on mesic sites such as lower parts of the slopes and around the villages. The most preserved forests of the community are formed with trees of dbh 30 cm and canopy coverage of 90%. *Quercus acutissima* community stands may distribute below 300 m in altitude, $10°\sim15°$ in slope degree and SW~SE in slope aspect. The forests are considered as topographic or edaphic climax conditions. In the tree layer *Quercus mongolica* and *Q. serrata* occur abundantly and *Prunus sargentii, Sorbus alnifolia, Alnus hirsuta* and *Fraxinus rhynchophylla* are rarely found. *Stephanandra incisa* often dominates other species such as *Rhododendron mucronulatum, R. schlippenbachii, Symplocos chinensis* for. *pilosa, Lindera obtusiloba* and *Lespedeza bicolor* in the shrub layer. The herbs of *Carex lanceolata, Spodiopogon cotulifer, Artemisia keiskeana* and *Partenocissus tricuspidata* live in undergrowth.

***Robinia pseudoacacia* plantation(Table 1-6)**

This is the forest planted on the lower slope, destroyed sites. Undergrowth of this forest is very poor.

***Alnus hirsuta* plantation(Table 1-7)**

This is the forest planted on the upper slope, destroyed sites.

***Alnus hirsuta* var. *microphylla* plantation(Table 1-8)**

This is the forest planted on the streamsides.

***Pinus densiflora* community(Table 1-9)**

The pine forests occur more abundantly on the sunny steep sides and xeric hillsides. This seems to be a forest developed secondarily on the destroyed sites.

***Pinus densiflora* - *Quercus acutissima* community**

This is the mixed forest of *Pinus densiflora* and *Quercus acutissima.*

***Pinus densiflora* - *Robinia pseudoacacia* community**

This is the pine forest mixed with *Robinia pseudoacacia.*

***Pinus rigida* plantation**

This is the forest planted on the lower slope, destroyed sites.

***Populus tomentiglandulosa* plantation**

This is the forest on the wet sites.

***Quercus mongolica* - *Alnus hirsuta* var. *sibirica* mixed forest**

This is the mongolian oak forest mixed with *Alnus hirsuta* var. *sibirica.*

Actual vegetation

In the actual vegetation map made of fourteen communities of *Pinus densiflora, Quercus mongolica, Q. mongolica - P. densiflora, Q. mongolica - Acer pseudo-sieboldianum, Q. variabilis, Q. acutissima, P. densiflora - Q. acutissima, Robinia pseudoacacia, P. densiflora - R. pseudoacacia, P. rigida, Populus tomentiglandulosa, Alnus hirsuta - A. hirsuta* var. *sibirica, A. hirsuta* var. *microphylla* and *Q. mongolica - A. hirsuta* var. *sibirica*(Fig. 3), four distributional forest types were divided: (1) *Quercus mongolica* forest type occured on upper parts of the mountain, (2) *Pinus densiflora* forest type on southern lower parts, (3) mixed forest type of *Q. mongolica* and *P. densiflora* on northern below mid-parts and (4) oak forest type of *Q. variabilis* and *Q. acutissima* forests on lower parts.

Q. variabilis, Q. acutissima and *P. densiflora* forests on lower parts seem to be the secondary forests reformed after destroyed by human activities. Most of the upper tree layer had been repeatedly cut for home use and the undergrowth also grazed for edible plants. Since appointed as the national park in 1983, however, the forests of the area have been preserved under the nature conservation law.

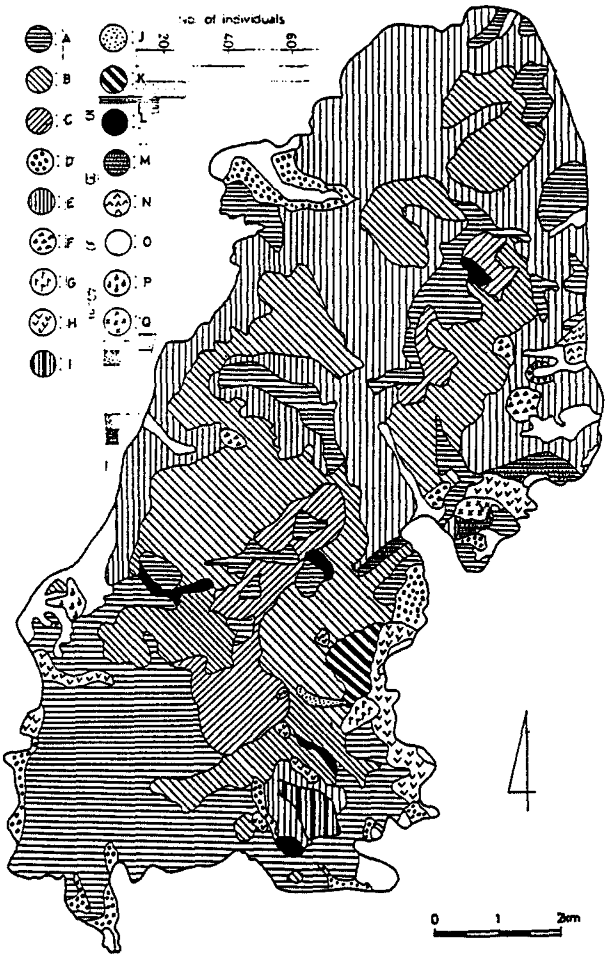


Fig. 3. Actual vegetation map of Pukhansan National Park. A=*Pinus densiflora* community, B=*Quercus mongolica*, C=*Q. mongolica-Acer pseudosieboldianum*, D=*Robinia pseudoacacia* plantation, E=*Q. mongolica-P. densiflora*, F=*Quercus variabilis*, G=*Pinus rigida* plantation, H=*Quercus acutissima*, I=*P. densiflora-Q. acutissima*, J=*Alnus hirsuta* var. *microphylla*, K=*Q. mongolica-A. hirsuta* var. *sibirica*, L=*A. hirsuta-A. hirsuta* var. *sibirica*, M=*P. densiflora-R. pseudoacacia*, N=*Populus tomentiglandulosa*, O=Urban area, P=Orchard and Q=Cemetery.

Changes in actual vegetation

Quercus serrata forest at 500 m in altitude (Fig. 4-A) is composed of *Q. serrata* in a few of large size trees and *Q. mongolica* in a number of small trees. The saplings of *Q. mongolica* in the forest are about quintuple of those of *Q. serrata*. It means that *Q. serrata* forest at above 500 m elevation of the mountain can be replaced by *Q. mongolica* forest in successional series. In *Pinus densiflora* forest at 490 m (Fig. 4-B) and *Q. acutissima* forest at 380 m (Fig. 4-C) in altitude, the similar tendencies are also shown.

Species diversity indices in different communities are calculated in large values of secondary forests such as *Q. serrata* 0.59, *Q. aliena* 0.54, *Q. variabilis* 0.66, *Q. acutissima* 0.70 and *Q. mongolica - P. densiflora* forest 0.49, while little values in natural forests such as *Q. mongolica* 0.18 and *P. densiflora* forest 0.06. It indicates the decreasing tendency of species diversity in successional series, as pointed by Despain (1983).

Potential natural vegetation

The successional pathways of late stage from the *Pinus densiflora* forest to the climatic climax were suggested by the size-distribution analysis recently. Five modes were recognized: the three pathways in Kwangneung forest communities (Kim 1977), the two pathways in Seonunsan Provincial Park area (Kim and Yim 1987) and in Tokyusan National Park area (Kil and Kim 1996), the three pathways in Naejangsan National Park area (Kim and Yim 1988b) and Chirisan National Park area (Yim and Kim 1992). According to the previous papers about successional tendency, the mongolian oak (*Q. mongolica*) forest and hornbeam (*Carpinus laxiflora*) forest are climatic climax forests in the cool-temperate zone, the deciduous broad-leaved forest zone of Korea.

Considering the successional tendency of secondary forests in cool temperate zone of Korea and the results of phytosociological classification, analyses of age structure and species diversity of different community in Pukhansan National Park area, two pathways of late successional stage from the *P. densiflora* forest to the climatic climax in the mountain were suggested. The first is fromthrough *Q. serrata* forests to *Q. mongolica* forests on above 200 m in altitude of the mountain, the second fromthrough

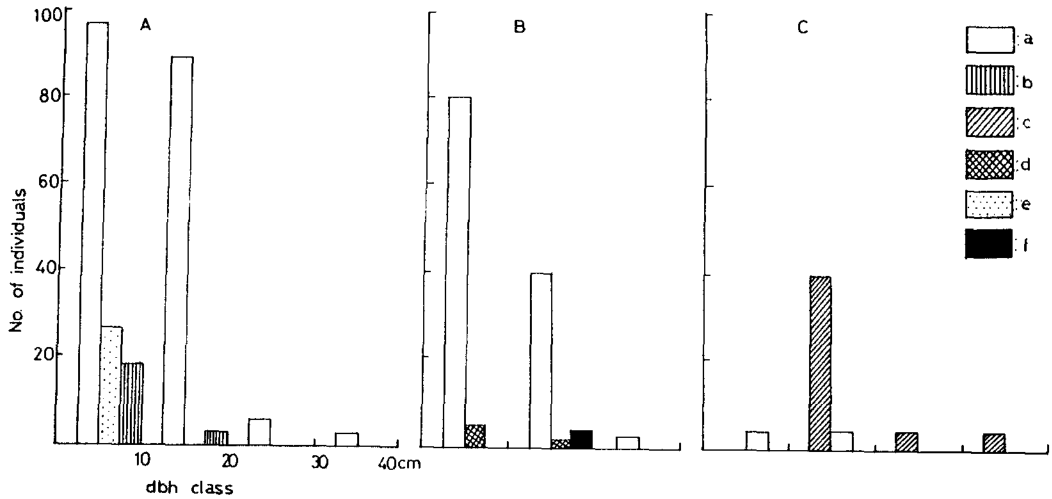
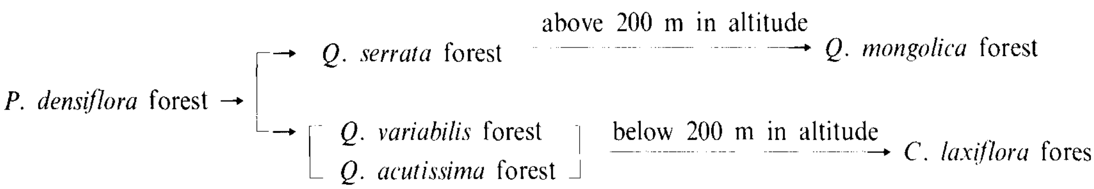


Fig. 4. Figures revealing the structures of dbh size class in some communities. A=*Quercus serrata* community at 500m in altitude, B=*Pinus densiflora* community at 490m and C=*Quercus acutissima* community at 380m. a=*Q. mongolica*, b=*Q. serrata*, c=*Q. acutissima*, d=*Q. aliena*, e=*Sorbus alnifolia* and f=*P. densiflora*.



Q. variabilis or *Q. acutissima* forests to *Carpinus laxiflora* forests on below 200 m in altitude of the mountain including the plantation, respectively.

P. densiflora forests on hillock or exposed ridge line and *Zelkova serrata* forests on well drained stony slopes or mountainstream sides may be considered as a topographic or edaphic climax forest in the mountain as in Chirisan (Yim and Kim 1992), Naejangsan (Kim and Yim 1988b) and Tokyusan National Park area (Kil and Kim 1996). Therefore, the potential natural vegetation of the park area will be mainly composed of *Q. mongolica, C. laxiflora, P. densiflora* and *Z. serrata* forest (Fig. 5).

The differences between the actual vegetation and potential natural vegetation map were found in the large area destroyed by human activities except areas around the temples and the steep slopes. The destroyed areas and plantations of introduced species should be afforestation of the plants native to Korea to form good natural vegetation, and the protection of natural vegetations and the afforestation planned for potential natural vegetations mentioned above are required for the restoration of nature.

The actual vegetation and potential natural vegetation map and/or many informations obtained in this study such as destroyed areas and plantations of introduced species will be contributed to the nature conservation.

摘 要

北漢山國立公園 地域 森林群集의 分類와 野外 調査를 통하여 만들어진 14個 群落을 包含하는 1:25,000 縮圖의 現存植生圖를 基礎로 同 地域의 潛在自然植生의 分布를 推察하였다. 이들 植物群落들의 種의 多樣度, 年齡 階級을 分析하고 人爲的 影響 등을 考慮하여 陽樹林인 소나무림으로부터 始作하여 氣候的 極相에 이르는 다음과 같은 2가지 系列, 즉 졸참나무림을 거쳐 신갈나무 極相

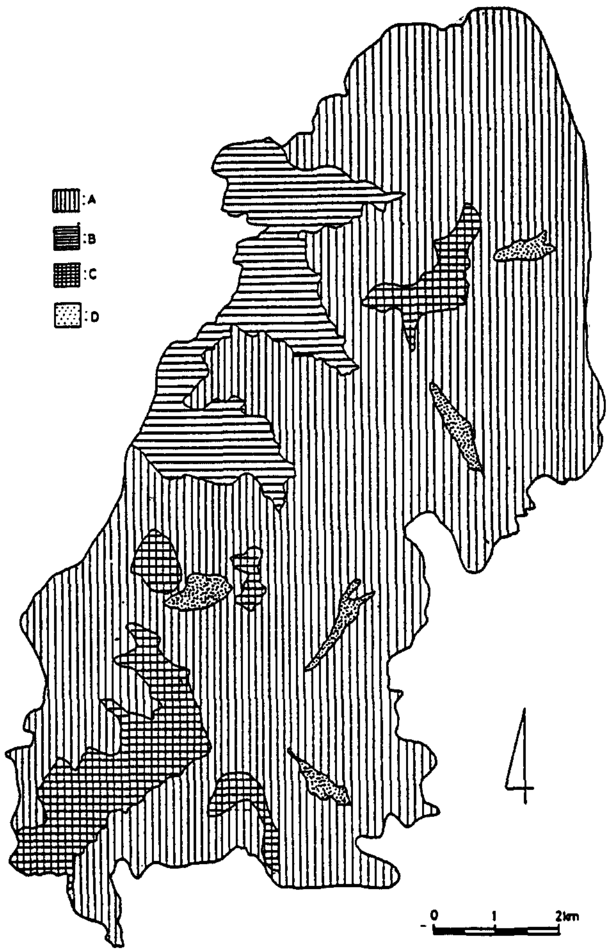


Fig. 5. Potential natural vegetation map of Pukhansan National Park. A=*Quercus mongolica* forest, B=*Carpinus laxiflora*, C=*Pinus densiflora* and D=*Zelkova serrata*.

林에 이르는 過程과 굴참나무림 또는 상수리나무림을 거쳐 서어나무 極相林에 이르는 過程이 있음이 밝혀졌다. 따라서 同 地域의 潛在自然植生은 氣候와 地形 또는 土壤的 條件에 따라 신갈나무, 서어나무, 소나무와 느티나무의 極相林으로 이루어질 것으로 보인다.

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