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Environmental Gradient Analyses of Forest Vegetation of Mt. Naejang, Southwestern Korea

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內藏山 森林植生의 環境傾度分析

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ABSTRACT

The environmental gradient analyses were applied for the ordination of forest vegetation in Mt. Naejang national park area in Korea. The species population sequence along soil moisture gradient, mesic to xeric, was shown in following order: *Zelkova serrata*, *Celtis sinensis*, *Lindera erythrocarpa*, *Cornus controversa*, *Acer mono*, *Carpinus tschonoskii*, *Quercus aliena*, *Daphniphyllum macropodum*, *Torreya nucifera*, *Carpinus laxiflora*, *Quercus serrata*, *Quercus variabilis*, *Quercus mongolica* and *Pinus densiflora* in tree species and *Acer pseudo-sieboldianum* var. *koreanum*, *Lindera obtusiloba*, *Styrax obassia*, *Styrax japonica*, *Acer pseudo-sieboldianum* and *Rhododendron schlippenbachii* in shrub species. Ten ecologiccal groups of trees were grouped and coincided with the vegetational units in phytosociological classification by Z-M method, associations. Four vegetation types, cove forest with *Zelkova serrata* and *Lindera erythrocarpa*, hornbeam forest with *Carpinus laxiflora* and *Carpinus tschonoskii*, oak forest with *Quercus variabilis* and *Quercus mongolica* and pine forest with *Pinus densiflora* as the dominant species were separated in mosaic chart by the two dimensional analyses of elevation and soil moisture gradient.

INTRODUCTION

The concept of environmental gradient analysis does not differ in principle from the approachs of ecological species group derivation and ecological classification. All three relate to the analysis of species and community distribution along known environmental gradient (Mueller-Dombois and Ellenberg, 1974). The approach from environment to floristic analysis, direct gradient analysis (Whittaker, 1967) contributes greatly to elucidation of the underlying cause of plant and community distribution. However, cause and effect relations at finer levels of plant distribution are difficult to detect through field observations. Such a weak point could be supplemented through experiment or comparison with another approach.

In the description of plant community the differences between the classification approach by the floristic composition and the ordination approach by the distribution of species populations have been pointed out by many investigators (Whittaker, 1967; Shimwell, 1971; Mueller-Dombois and Ellenberg, 1974; Krebs, 1978). The main objection to the two approaches is that the classification approach is too subjective and therefore cannot answer the ecological question of whether communities have sharply defined their boundaries and the ordination approach is insufficient to test the community unit hypothesis because stands studied are not homogeneous. The result of study which was designed to test the community unit theory and individualistic hypothesis by Whittaker (1967) supported Gleason's ideas, species individuality and community continuity. According to him, communities are not discrete but grade continuously in space and in time and species groups are inconsistent from place to place (Whittaker, 1951; 1956; 1967; Peet and Loucks, 1977). According to Walter (1971) a plant community is understood to be a more or less stable combination of naturally occuring species, which are in an equilibrium with one another and their environment. Therefore, integration is considered to be a prerequisite for recognizing a plant grouping as a community by many investigators (Poore, 1964).

In this study, to solve the integration problem of species population-to-community environmental gradient, analyses for the forest of Mt. Naejang were carried out by comparing with the results of phytosociological classification (Kim and Yim, 1988).

METERIALS AND METHODS

Vegetation survey. The data on the floristic composition and habitat conditions recorded by Kim and Yim (1988) and the census for 3 cm<dbh trees in 86 quadrats of 10×10 m size at random were used for the environmental gradient analyses. Soils of A horizon in each quadrat were air-dried and sifted by a 20-mesh sieve for chemical analyses and a 60-mesh for organic matter measurement (Kim *et al.*, 1986). Soil pH was determined in soil solution (soil:dist. water=1:5, w/v) by glass electrode. Soil moisture content was calculated as a percentage of loss water against dry soil weight at 105 ℃. Soil organic matter content was determined as a percentage of the loss-on-ignition against dry soil weight.

Gradient analyses. As the key factor of soil condition, soil moisture, pH and organic matter content were selected. Soil moisture, pH and organic matter content were standardized in a scale of 1 to 10. respectively (Whittaker, 1967). Importancce values for dominant trees calculated as the sum of relative density, relative coverge and relative frequency (Curtis and McIntosh, 1951) were plotted along the gradient of soil moisture, soil pH or organic matter content, rank 1 to 10.

Pattern analyses. For the environmental pattern analyses of two complex gradients, elevation and topographical moisture gradient were used as the axes of charts and vegetation types are plotted on the chart (Whittaker, 1956; 1967). A mesic to xeric change, moisture gradient, in the mountain was determined with soil moisture and topographic categories such as sheltered slopes and open slopes or coves and ridges, etc. The importance values of dominant species population were used for population charts and then the mosaic chart for vegetation patterns was constructed.

RESULTS AND DISCUSSION

Distribution of species population along environmental gradient. The effect of moisture gradient on the distribution of species populations was most evident among the environmental factors examined. Different species populations along soil moisture gradient showed a bell-shaped curves with single peak in different classes, respectively. The peaks of different species from mesic to xeric sites showed the sequence of *Zelkova serrata, Celtis sinensis, Lindera erythrocarpa, Cornus controversa, Acer mono, Carpinus tschonoskii, Quercus aliena, Daphniphyllum macropodum, Torreya nucifera, Carpinus laxiflora, Quercus serrata, Quercus variabilis, Quercus mongolica and Pinus densiflora* in tree species and of *Acer pseudo-sieboldianum* var. *koreanum, Lindera obtusiloba, Styrax obassia, Styrax japonica, Acer pseudo-sieboldianum* and *Rhododendron schlippenbachii* in shrub species (Fig. 1). With the basis of the behaviors of tree and shrub species in the same peak class, ten ecological groups (Ellenberg, 1956) were divided: *Acer mono-Zelkova serrata, Torreya nucifera, Cornus controversa-Lindrea erythrocarpa, Quercus aliena-Carpinus tschonoskii, Carpinus tschonoskii, Daphniphyllum macropodum, Carpinus laxiflora, Quercus variabilis, Rhododendron schlippenbachii-Quercus mongolica, Rhododendron mucronulatum-Pinus densiflora* group. These groups are coincided with communities of ten units in phytosociological classification and with the species associations of ten groups in correlaton analysis as in Mt. Seonun (Kim and Yim, 1986; 1988).

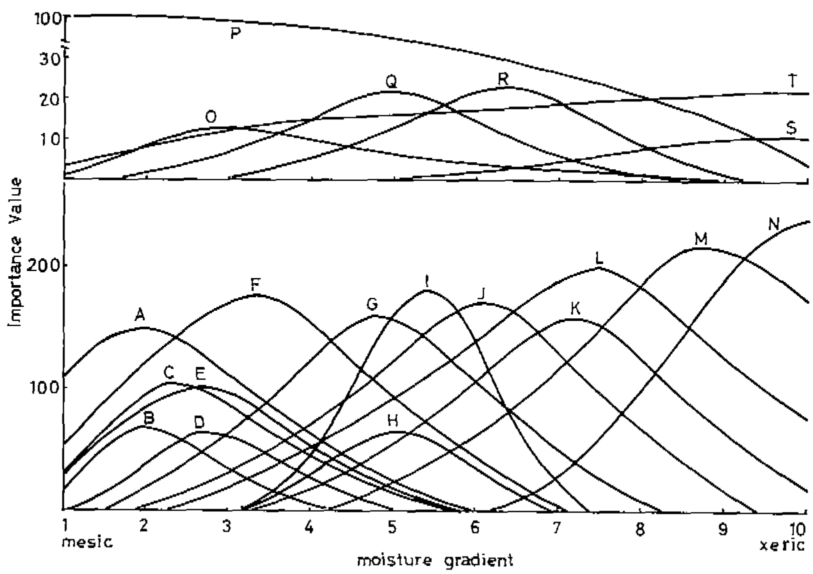
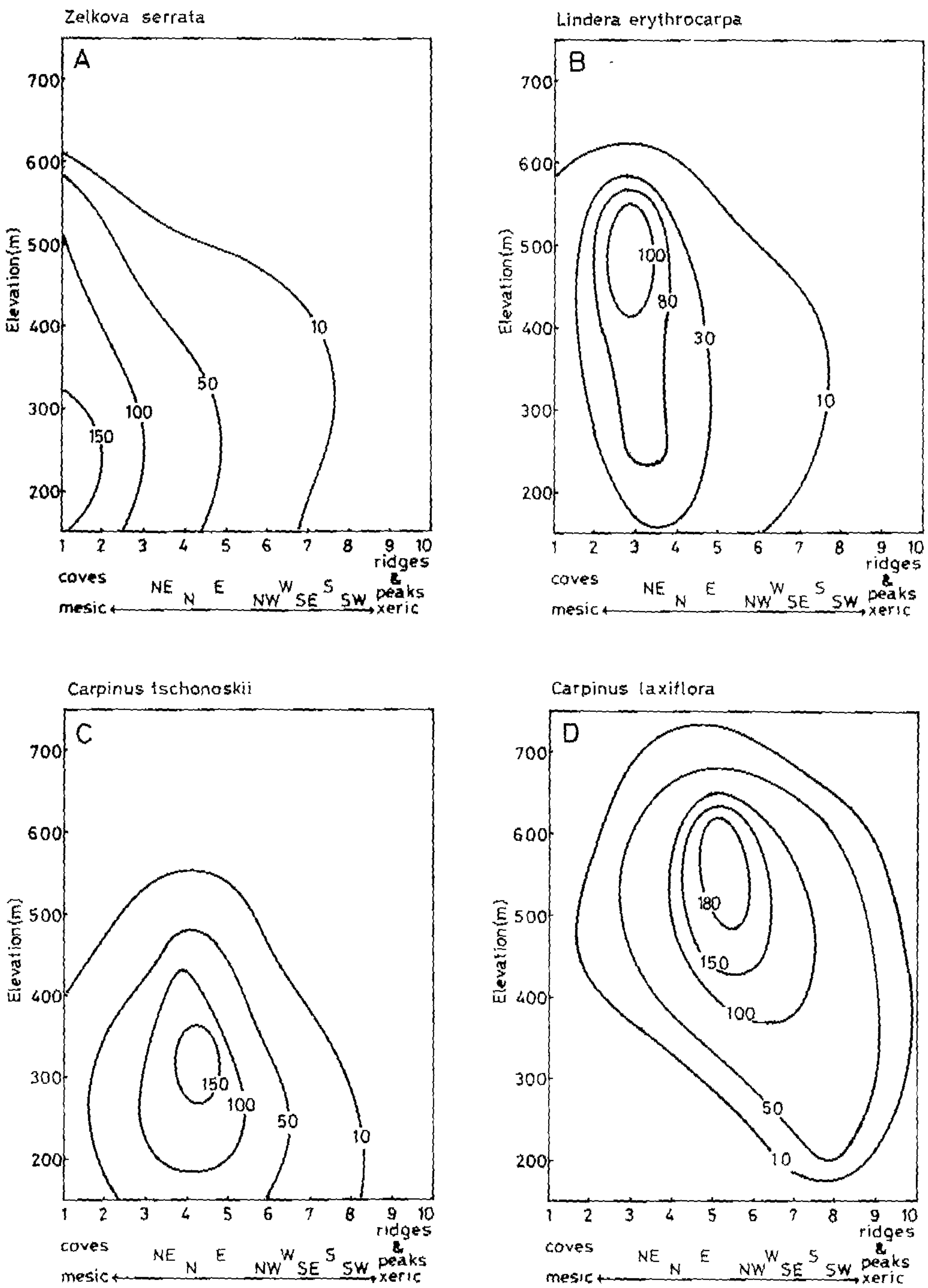
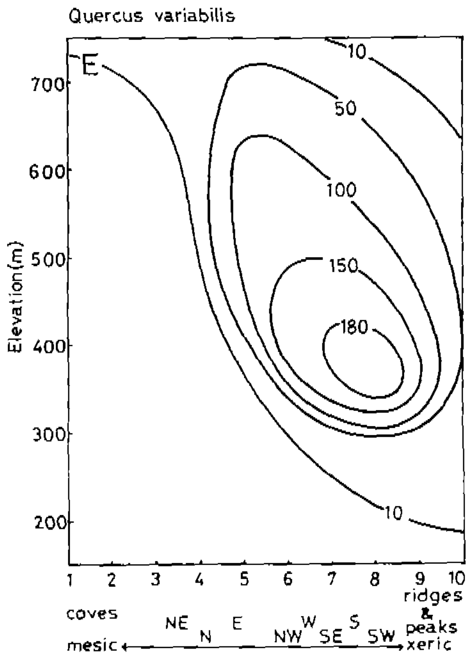
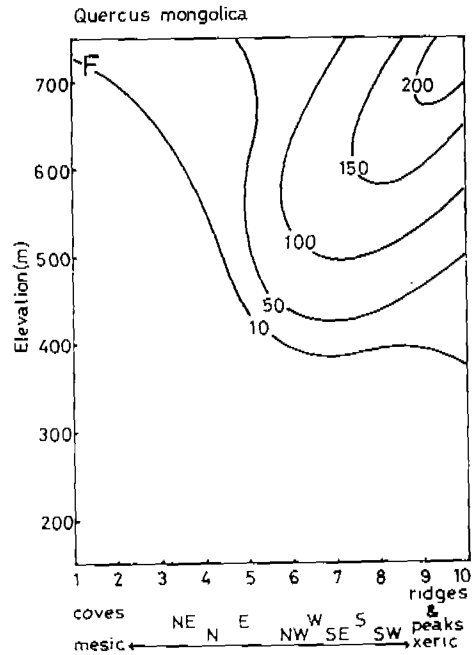


Fig. 1. Importance value curves of 20 species population along moisture gradient in Mt. Naejang. Upper side: shrub species, under side: tree species. A: *Zelkova serrata,* B: *Celtis sinensis,* C: *Linera erythrocarpa,* D: *Cornus controversa,* E: *Acer mono,* F: *Carpinus tschonoskii,* G: *Quercus aliena,* H: *Daphniphyllum macropodum,* I: *Torreya nucifera,* J: *Carpinus laxiflora,* K: *Quercus serrata,* L: *Quercus variabilis,* M: *Quercus mongolica,* N: *Pinus densiflora,* O: *Lindera obtusiloba,* P: *Acer pseudo-sieboldianum* var. *koreanum,* Q: *Styrax obassia,* R: *Styrax japonica,* S: *Rhododendron schlippenbachii,* T: *Acer pseudo-sieboldianum.*



Zelkova serrata
A
Elevation(m)
700
600
500
400
300
200
150
100
50
10
1 2 3 4 5 6 7 8 9 10
ridges & peaks
coves
NE N E NW W SE S SW
mesic ← → xeric
Lindera erythrocarpa
B
100
80
30
10
Carpinus tschonoskii
C
150
100
50
10
Carpinus laxiflora
D
180
150
100
50
10





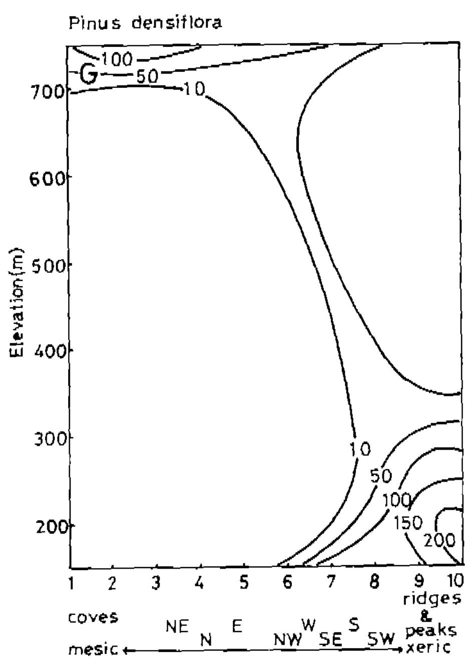


Fig. 2. Population charts for seven dominant species in Mt. Naejang, Korea.
A: *Zelkova serrata*, B: *Lindera erythrocarpa*, C: *Carpinus tschonoskii*, D: *Carpinus laxiflora*, E: *Quercus variabilis*, F: *Quercus mongolica*, G: *Pinus densiflora*. Arabic numerals on the lines stand for the isopleth of importance values of each species. The vertical axis is the complex gradient of temperature related to elevation and other factors such as soil nutrient; the horizontal axis is the complex gradient of soil moisture and other factors such as light intensity or topography.

Vegetation pattern. The results of the environmental pattern analysis with temperature (elevation) and moisture (or topographic) gradient showed that the species were distributed continuously quite according to the Gleason's principle of species individuality (Whittaker, 1967) and were arbitrarily grouped into ten sets of species having same population centers or close together (Fig. 2). The distribution center of ten sets of species populations was found in characteristic sites one another: *Zelkova serrata* population in mesic-lower parts near the mountain stream and well drained stony slopes (Fig. 2A); *Torreya nucifera* and *Daphniphyllum macropodum* population in mesic-warm sites of the coves; *Lindera erythocarpa* population in mesic-stony sites of the coves (Fig. 2B); *Quercus aliena* population in mesic-lower sites; *Carpinus tschonoskii* population in mesic-lower parts of the slope in the mountain (Fig. 2C); *Carpinus laxiflora* population in mesic-middle parts of the slope (Fig. 2D); *Quercus variabilis* population in xeric-middle parts of the slope (Fig. 2E); *Quercus mongolica* population in xeric-upper parts of the slope (Fig. 2F); *Pinus densiflora* population in xeric-rock ridge line and hillock, dry and poor habitat, and in lower parts destroyed by human activities (Fig. 2G). *Zelkova serrata, Lindera erythrocarpa* and *Carpinus tschonoskii* seem to be strong shade tolerant species considering their mesic-shade habitats.

The vegetation patterns of Mt. Naejang by mosaic chart based on population charts showed four vegetation types: cove forest with *Zelkova serrata* and *Lindera erythrocarpa* in coves and stony slopes, hornbeam forest with *Carpinus laxiflora* and *Carpinus tschonoskii* in middle-humid parts, oak forest with *Quercus variabilis* and *Quercus mongolica* in upper-xeric parts and pine forest with *Pinus densiflora* in xeric hillsides and ridges (Fig. 3).

As mentioned above ten ecological groups by moisture gradient analysis coincide with ten species populations by two dimensional analysis of temperature-moisture gradient and they

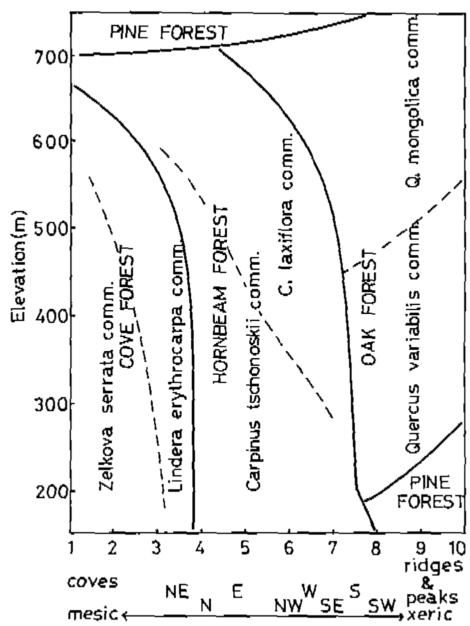


Fig. 3. Mosaic chart for vegetation pattern in relation to elevation and topography in Mt. Naejang, Korea.
The pattern is based on 86 samples plotted by elevation and topography position; the lines mark out in the comtinuous community types of the phytosociological classification (Kim and Yim, 1988).

coincide with ten communities by phytosociological classification with Z-M method. Therefore, species groups by environment analysis can be identically recognized as communities by floristic analysis.

摘　　要

內藏山 國立公園의 森林植生을 傾度分析에 의하여 類別하고 Z-M學派의 方法에 따른 分類結果와 比較하여 兩者 사이의 一致性을 檢討하였다. 適濕地로부터 乾燥地에 이르는 土壤濕度傾度에 따른 種集團의 配列은 喬木層에서 느티나무, 팽나무, 비목나무, 층층나무, 고로쇠나무, 개서어나무, 갈참나무, 굴거리나무, 비자나무, 서어나무, 졸참나무, 굴참나무, 신갈나무와 소나무의 順이었고 灌木層에서는 좁은단풍, 생강나무, 쪽동백나무, 때죽나무, 당단풍과 철쭉꽃의 順이었다. 이들의 生態的 行動에 따라 類別된 10個의 生態群은 Z-M方法에 의해 分類된 群集들과 一致하였다. 高度와 土壤濕度의 二次元分析에서는 느티나무와 비목나무로 優占된 溪谷林, 서어나무와 개서어나무로 이루어진 中斜面의 서어나무林, 굴참나무와 신갈나무로 이루어진 上部斜面의 참나무林과 乾燥한 山頂部의 소나무林의 4個의 植生型으로 類別되었다.

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