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A Gradient Analysis of the Mixed Forest of Seonunsan Area in Southwestern Korea

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禪雲山地域 森林群集의 傾度分析

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ABSTRACT

The environmental gradient analyses and the continuum analyses were applied for the ordination of forest vegetation in Seonunsan area.

In the soil moisture gradient, mesic to xeric, *Zelkova serrata*, *Carpinus tschonoskii*, *Quercus aliena*, *Carpinus laxiflora*, *Quercus serrata*, *Quercus variabilis* and *Pinus densiflora* type were arranged as a series of sequence along the gradient. In two dimensional analyses of soil moisture and organic matter gradients seven vegetation types mentioned above were also separated one another. Especially *Carpinus tschonoskii* in mesic-fertile sites and *Pinus densiflora* in xeric-sterile were noticeable.

The results of continuum analyses were corresponded to those of environmental gradient analyses for the forest vegetation.

INTRODUCTION

The difference between the classification approach by floristic composition and the ordination approach by the distribution of species populations have been pointed out by many investigators (Whittaker, 1967; Krebs, 1978; Mueller-Dombois and Ellenberg, 1974). According to Whittaker (1951, 1956) and others (Peet and Loucks, 1977; Weger *et al.*, 1983), communities are not discrete but grade continuously in space and in time, and species groups are inconsistent from place to place. In spite of this continuous variation, it is said that communities can be classified (Kim and Yim, 1986; Kim *et al.*, 1986; Nakanishi, 1982, 1985; Toyohara *et al.*, 1983; Miyawaki *et al.*, 1981; Hada and Itow, 1980). In this study a direct gradient analysis or environmental gradient analysis (Whittaker, 1951, 1956, 1967) and indirect gradient analysis or continuum analysis (Curtis and McIntosh, 1951; Bray and Curtis, 1957; Curtis, 1959) for the forest of Seonunsan provincial park were carried out to compare with the results of phytosociological classification (Kim and Yim, 1986).

METERIALS AND METHODS

Vegetation survey The data on floristic composition and habitat conditions recorded in Seonunsan provincial park by Kim and Yim (1986) from Aug. 1985 to Aug. 1986 and the census for trees over 3 cm in dbh obtained from 33 quadrats in (10×10)m size set up were used for the ordination techniques. Importance values were calculated by relative density, relative coverage and relative frequency (Curtis and McIntosh, 1951).

Soils collected from B horizon in each quadrat were air-dried and sifted with a 20-mesh sieve for chemical analysis and a 60-mesh for measurement of organic matter content (Kim *et al.*, 1986). Soil pH was determined in solution (soil:dist. water=1:5, w/v) by grass electrode. Soil moisture content was calculated as a percentage of loss water against dry weight at 105°C. Soil organic matter content was determined as a percentage of the loss-on-ignition against dry weight.

Gradient analysis For direct gradient analysis or environmental gradient analysis, soil moisture, pH and organic matter content was standardized in a scale of 1 to 10, respectively (Whittaker, 1967). For indirect gradient analysis or continuum analysis, the species with highest importance value in each stand proved to be the leading dominant. The dominants with similar importance value were grouped and given an arbitrary rank value, climax adaptation number, from 1 to 10 (Brown and Curtis, 1952).

The continuum index for each stand was calculated by importance value and climax adaptation number, and importance value was used for Y axis against X axis, continuum index.

RESULTS AND DISCUSSION

The distribution of tree species populations along soil moisture gradient almost showed a bell-shaped curves having single peak in different classes. From mesic to xeric sites, the peaks of different species showed the sequence of *Zelkova serrata*, *Carpinus tschonoskii*, *Quercus aliena*, *Carpinus laxiflora*, *Quercus serrata*, *Quercus variabilis* and *Pinus densiflora* (Fig. 1).

The behavior of shrub in an arrangement of simple ordination was similar to those of major trees and a group of tree and shrub species in the same site was coincided with a ecological species groups in phytosociology, such as a group of *Pinus densiflora* and *Rhododendron mucronulatum*. As a result of this ordination, *Rhododendron mucronulatum*—*Pinus densiflora*, *Quercus variabilis*, *Quercus serrata*—*Carpinus tschonoskii*, *Carpinus laxiflora*, *Quercus aliena*—*Carpinus tschonoskii*, *Carpinus tschonoskii* and *Orixa japonica*—*Zelkova serrata* community were also grouped as different types in phytosociological classification.

Environmental pattern analysis of seven groups mentioned above, for the relation of two or more gradients, for example, in the organic matter gradient and the moisture

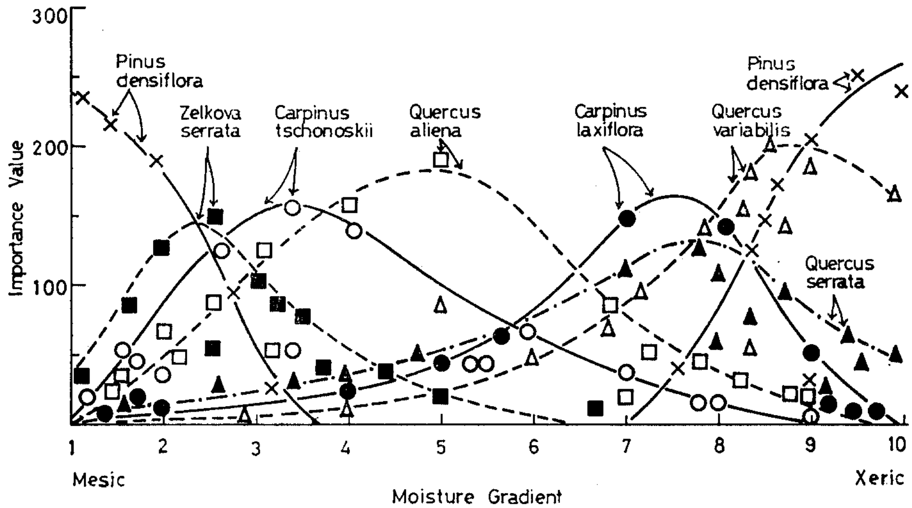

Fig. 1. Importance value curves of species population along an environmental gradient, moisture, in Seonunsan.

gradient ordination, were scattered distinctively along the two axes with a few exceptions. From mesic-fertile to xeric-sterile site, the groups were showed the sequence of *Carpinus tschonoskii, Orixa japonica—Zelkova serrata, Quercus aliena—Carpinus tschonoskii, Quercus serrata—Carpinus tschonoskii, Carpinus laxiflora, Quercus variabilis* and *Rhododendron mucronulatum—Pinus densiflora* community (Fig. 2). In mesic-fertile sites *Carpinus tschonoskii* and in xeric-sterile *Pinus densiflora* showed stable stand. In organic matter and pH gradient ordination, the groups were in separable along the pH gradient axes. Because the pH variation was showed the narrow range of pH 4.3~5.3, it seems that the value could not operated as a limiting factor.

Seven groups were arranged along their average importance value of leading dominants obtained from 33 stands (Table 1). By the results, climax adaptation numbers, from rank 1 to 10, were arbitrary donated rank 1 for *Pinus densiflora* and rank 10 for *Zelkova serrata* in two end points and the intermediate ranks for subsidiary species based on similarities of importance value

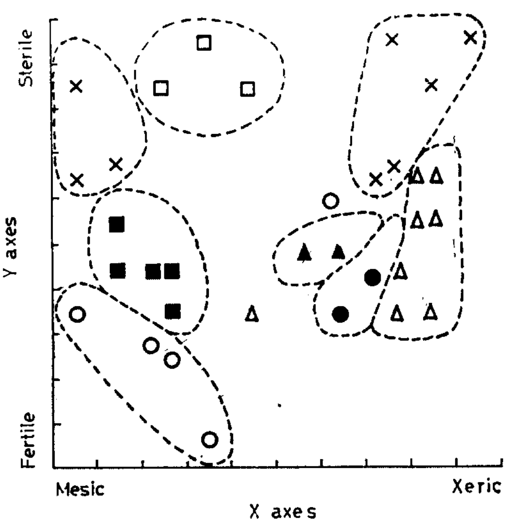

Fig. 2. Environmental pattern analysis for communities in relation to two gradients, moisture (X axes) and organic matter (Y axes). ×; *Pinus densiflora* community, ■; *Zelkova serrata* community, □; *Quercus aliena* community, ●; *Carpinus laxiflora* community, ○; *Carpinus tschonoskii* community, ▲; *Quercus serrata* community, △; *Quercus variabilis* community.

Table 1. Average importance value of trees in stands with given species as leading dominant—33 stands from forests of Seonunsan.

No. stands	Leading dominant	*Pinus densiflora*	*Quercus variabilis*	*Quercus serrata*	*Carpinus laxiflora*	*Quercus aliena*	*Carpinus tschonoskii*	*Zelkova serrata*
8	*Pinus densiflora*	**213**	36	29	6	17	3	—
8	*Quercus variabilis*	60	**146**	44	13	6	19	—
2	*Quercus serrata*	—	76	**112**	14	12	56	—
2	*Carpipus laxiflora*	—	76	13	**146**	23	—	—
3	*Quercus aliena*	13	20	22	—	**160**	25	19
5	*Carpinus tschonoskii*	—	15	43	7	54	**116**	32
5	*Zelkova serrata*	—	3	—	—	45	46	**92**

(Table 2).

The results of ordination against continuum index were similar to the patterns obtained in the environmental gradient analysis (Fig. 3). Communities were intergraded continuously along environmental gradients with gradual changes in species populations. It seems that the transitions between communities are not obvious and gradually changed from place to place or time to time as mentioned by McIntosh (1967). On the other hand, the positive correlation (r=0. 70) between continuum index and soil moisture content was found as shown Fig. 4. Red pine stands were found in dry soils, whereas hornbeam (*Carpinus tschonoskii*) stands in wet soils. The soil moisture gradient act as a limiting factor in the area.

Table 2. Climax adaptation numbers of tree species found in stands of forests in Seonunsan.

Tree species	Climax adaptation number	Tree species	Climax adaptation number
Pinus densiflora	1	*Acer mono*	7
Juniperus rigida	1	*Acer pseudo-sieboldianum* var. *koreanum*	7
Quercus variabilis	2	*Fraxinus rhynchophylla*	7
Platycarya strobilacea	2	*Carpinus tschonoskii*	8
Quercus serrata	3	*Stylax japonica*	8
Fraxinus sieboldiana	3	*Cornus controversa*	9
Carpinus laxiflora	4	*Lindera erythrocarpa*	9
Carpinus cordata	4	*Celtis sinensis*	10
Prunus sargentii	5	*Zelkova serrata*	10
Quercus aliena	6		

Even though the two approaches, environmental gradient analysis and continuum analysis, were distinguished in ideas of gradient analysis but their results were convergent as mentioned above. It means that two different techniques essentially stand on same principle. In this study, the results of gradient analyses for the forest vegetation were corresponded to those of phytosociological classification in classifying vegetation. Consequently,

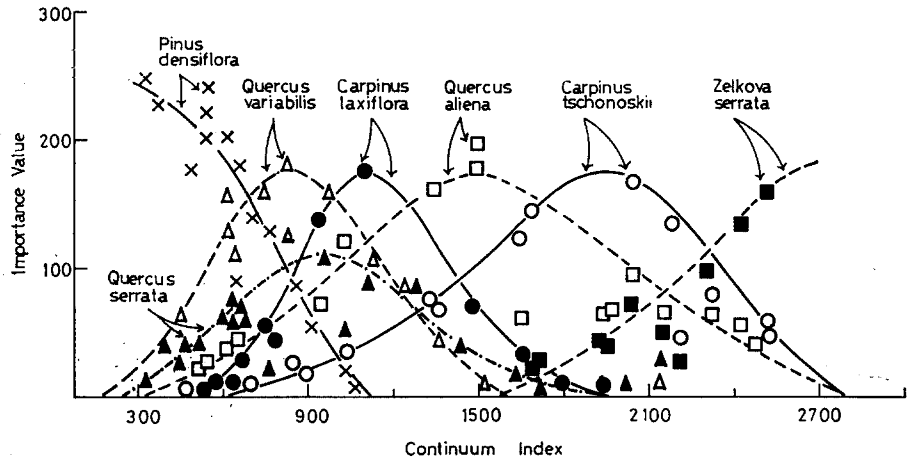

Fig. 3. Importance value curves for the seven leading tree species along a continuum gradient in Seonunsan.

the two methods, ordination and classification, can be used complementarily only where the degree of entitation and the sampling intensity are the same.

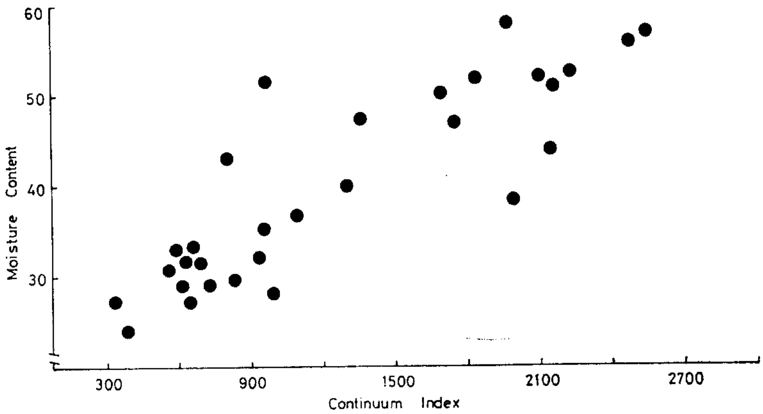

Fig. 4. Moisture content(%) of the B horizon of the soil in relation to the continuum of Seonunsan forests illustrated in Figure 3.

摘　要

前報에서 禪雲山 道立公園의 森林植生을 ZM學派의 方法에 따라 調査하고 植物群集을 分類하였던바 本報에서는 同森林植生을 傾度分析에 의하여 類別하고 兩者 사이의 一致性을 檢討하였다.

適濕地로부터 乾燥地로 土壤濕度傾度에 따른 植生群集型의 排列은 느티나무群集, 개서어나무群集, 갈참나무群集, 서어나무群集, 졸참나무群集, 굴참나무群集과 소나무群集의 順으로 나타났다. 土壤濕度—肥沃度의 二次元分析에서 適濕—肥沃한 곳에서는 개서어나무林이 그리고 乾燥—瘠薄한 곳에서는 소나무林이 나타나는 傾向이 있었다. 連續指數에 의한 分析에서도 環境傾度分析과 類似한 結果를 얻었다. 이러한 傾度分析의 結果들은 分類法에 의한 것과 一致하였다. 따라서 이들 두 方法은 서로 相補的으로 使用될 수 있음이 立證되었다.

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