Korean J. Ecol. 11(3) : 131~136, 1988

Indirect Ordination of the Forest Communities of Mt. Naejang, Southwestern Korea

Kim, Jeong-Un and Yang-Jai Yim

(Department of Biology, Chung-ang University)

間接 序列法에 依한 內藏山 森林群集 分析

金 正 彥 · 任 良 宰

(中央大學校 生物學科)

ABSTRACT

The continuum analyses and polar ordinations were applied for the ordination of forest vegetation in Mt. Naejang, national park in Korea. In the continuum analyses the sequence of *Pinus densiflora*, *Quercus mongolica*, *Quercus variabilis*, *Carpinus laxiflora*, *Carpinus tschonoskii*, *Lindera erythrocarpa* and *Zelkova serrata* community was arranged along the continuum gradient as in moisture gradient analyses. The positive correlation of r=0.83 between continuum index and soil moisture content was observed. In the polar ordinations ten communities of *Pinus densiflora*, *Quercus mongolica*, *Quercus variabilis*, *Carpinus laxiflora*, *Daphniphyllum macropodum*, *Carpinus tschonoskii*, *Quercus aliena—Carpinus tschonoskii*, *Torreya nucifera*, *Cornus controversa—Lindera erythrocarpa* and *Zelkova serrata* were identified. However, continuous distribution pattern of ten communities mentioned above could be regarded as a vegetational continuum. The results of these ordinations also were corresponded to those of phytosociological classification.

INTRODUCTION

Curtis and McIntosh (1951) asserted that the vegetational continuum appears to substantiate Gleason's individualistic hypothesis, and Curtis (1959) regarded the evidence adduced in vegetational studies in Wisconsin as conclusive proof of Gleason's hypothesis. Whittaker (1956) interpreted the continuum as evidenced in his studies, environmental gradient analysis, as grounds for rejecting the community unit theory in favor of the individualistic concept. These two approaches, environmental gradient analysis and continuum analysis, were distinguished in ideas of gradient analysis. That is, in the former, may be termed direct gradient analysis originally applied by Whittaker (1951) in his criticism and consideration of climax concepts, the vegetation samples are arranged in positions along an environmental gradient and in the latter, called indirect gradient analysis, the samples are compared with one another usually in terms of species composition and then arranged along axes based on their similarities measured. Both methods, however, emphasize the continuity of vegetation and seek to demonstrate a continuum rather than a classification (Shimwell, 1971).

In the present study continuum analysis and polar ordination were carried out to compare with the results of environmental gradient analyses and of phytosociological classification (Kim and Yim, 1988a, b) for the forest of Mt. Naejang.

MATERIALS AND METHODS

Data source

The data on floristic composition and habitat conditions and the census for tree populations recorded in 86 stands from Mt. Naejang by Kim and Yim (1988a, b) were used for the ordinations. Moisture content, organic matter and pH of soils in each quadrat determined for previous study (Kim and Yim, 1988b) were refered to the discussion in this study.

Continuum analyses

The leading dominants were determined the highest importance value in each stand. The dominants were grouped with similar importance value and arranged in the sequence with the basis of their similarities. Based on the sequence arbitrary rank values, climax adaptation numbers, were given to each species from 1 to 10. The continuum index (CI) for each stand was calculated from importance value (IV) and climax adaptation number (CAN), $CI=\sum(IV\cdot CAN)$, by Brown and Curtis (1952). The importance values of all the tree species were used for Y axis against X axis in continuum index.

Polar ordination

Index of dissimilarity (ID) values obtained from index of similarity (IS) by Sørensen (1948), $ID=100-IS$, were used as a measure of distance for polar ordination, Wisconsin comparative ordination (Bray and Curtis, 1957). Distance values of X, Y and Z axis in each stand were calculated from Beal's formula (1960). By its X, Y and Z value, each stand position was plotted into a graph. Cannon CX-1 computer was used to the calculations for the ordinations.

RESULTS AND DISCUSSION

Continuity of vegetation

Nine types with different leading dominant, ***Pinus densiflora***, ***Quercus mongolica***, ***Quercus variabilis***, ***Carpinus laxiflora***, ***Daphniphyllum macropodum***, ***Carpinus tschonoskii***, ***Lindera erythrocarpa***, ***Torreya nucifera*** and ***Zelkova serrata*** stand types, corresponding to nine communities as in phytosociological classification (Kim and Yim, 1988a), were

Table 1. Average importance value of trees in stands with given species as leading dominant—86 stands from forests of Mt. Naejang

Leading dominant	Number of stands	*Pinus densiflora*	*Quercus mongolica*	*Quercus variabilis*	*Quercus serrata*	*Carpinus laxiflora*	*Daphniphyllum macropodum*	*Quercus aliena*
Pinus densiflora	7	**213**	—	8	2	—	—	—
Quercus mongolica	14	4	**135**	52	16	11	—	—
Quercus variabilis	26	—	9	**138**	32	16	—	3
Carpinus laxiflora	6	—	2	4	29	**122**	—	11
Daphniphyllum macropodum	3	—	—	—	10	64	**36**	—
Carpinus tschonoskii	11	2	—	8	16	6	—	33
Lindera erythrocarpa	6	—	—	—	9	10	3	—
Torreya nucifera	7	—	—	—	—	1	—	12
Zelkova serrata	6	—	—	2	1	7	—	6

	Number of stands	*Carpinus tschonoskii*	*Lindera erythrocarpa*	*Cornus controversa*	*Torreya nucifera*	*Acer mono*	*Celtis sinensis*	*Zelkova serrata*
Pinus densiflora	7	—	—	1	—	—	—	1
Quercus mongolica	14	2	—	—	—	1	—	—
Quercus variabilis	26	2	7	2	—	1	1	3
Carpinus laxiflora	6	2	15	17	—	9	—	—
Daphniphyllum macropodum	3	24	17	8	—	4	—	—
Carpinus tschonoskii	11	**120**	7	6	—	3	2	4
Lindera erythrocarpa	6	4	**80**	39	—	29	20	17
Torreya nucifera	7	—	2	7	**148**	3	4	17
Zelkova serrata	6	1	22	10	1	37	13	**96**

grouped when arranged with the similarities between stands (Table 1). Based on the arrangement climax adaptation numbers of tree species found in stands of forest were given rank 1 for *Pinus densiflora* and rank 10 for *Zelkova serrata* in two end points (Table 2).

Excepting the two communities of *Daphniphyllum macropodum* and *Torreya nucifera* regarded as the relic stands, seven communities of *Pinus densiflora*, *Quercus mongolica*, *Quercus variabilis*, *Carpinus laxiflora*, *Carpinus tschonoskii*, *Lindera erythrocarpa* and *Zelkova serrata* were arranged as a sequence in the ordination against the continuum index, showing the pattern as in the environmental gradient analysis (Fig. 1). It means that the transitions between communities are not obvious, but gradually changed from place to place

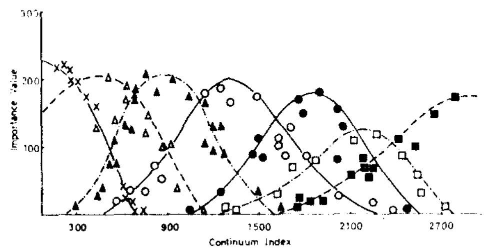

Fig. 1. Importance value curves for the seven leading tree species along continuum gradient in Mt. Naejang. ×—× : *Pinus densiflora*, △--△ : *Quercus mongolica*, ▲-·-▲ : *Quercus variabilis*, ○—○ : *Carpinus laxiflora*, ●—● : *Carpinus tschonoskiii*, □-·-□ : *Lindera erythrocarpa*, ■--■ : *Zelkova serrata*.

Table 2. Climax adaptation numbers of tree species found in stands of forest in Mt. Naejang

Tree species	Climax adaptation number
Pinus densiflora	1
Juniperus rigida	1
Quercus mongolica	2
Acer pseudo-sieboldianum	2
Quercus variabilis	3
Fraxinus sieboldiana	3
Platycarya strobilacea	3
Quercus serrata	4
Prunus sargentii	4
Carpinus laxiflora	5
Carpinus cordata	5
Styrax obassia	5
Torreya nucifera	6
Daphniphyllum macropodum	6
Sapium japonicum	6
Quercus aliena	7
Fraxinus rhynchophylla	7
Lindera obtusiloba	7
Carpinus tschonoskii	8
Acer pseudo-sieboldianum var. *koreanum*	8
Meliosma myriantha	8
Styrax japonica	8
Lindera erythrocarpa	9
Cornus controversa	9
Acer mono	9
Zelkova serrata	10
Celtis sinensis	10

or time to time as mentioned by McIntosh (1967).

On the other hand, the positive correlation (r=0.83) between continuum index and soil moisture content was suggested (Fig. 2). Red pine and mongolian oak stands were observed on dry soil, whereas *Zelkova* and hornbeam stands on wet soil. The soil moisture gradient seems to be act as a limiting factor in this mountain as in Mt. Seonun (Kim and Yim, 1986). Therefore, even though the two approaches were distinguished in different two ideas of environment-to-community and community itself but the results fo two approaches were same in the identification of natural vegetation. It means that two different techniques essentially bring to the same result of community analysis.

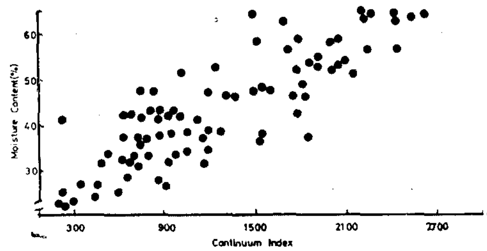

Fig. 2. Moisture content (%) of the A horizon of the soil in relation to the continuum of Mt. Naejang forests illustrated in Fig. 1.

Polar ordination

In Y/X ordination (Fig. 3) of the 86 stands, ten separate groups of ***Pinus densiflora***, ***Quercus mongolica***, ***Quercus variabilis***, ***Carpinus laxiflora***, ***Daphniphyllum macropodum***, ***Carpinus tschonoskii***, ***Quercus aliena-Carpinus tschonoskii***, ***Torreya nucifera***, ***Cornus controversa-Lindera erythrocarpa*** and ***Zelkova serrata*** were similar to the results of classification, environmental gradient analyses (Kim and Yim, 1988a, b) and continuum analyses. The sequence of these groups along two axis, from upper left to lower right of the graph, was also coincided with that of species populations along the moisture gradient and well separated one another with a few exceptions. That is, the stands of ***Quercus variabilis*** community were intermingled in ***Quercus mongolica*** and ***Carpinus laxiflora*** community and the stands of ***Daphniphyllum macropodum*** and ***Quercus aliena*** community in ***Carpinus tschonoskii*** community. However, the distributional pattern of ten

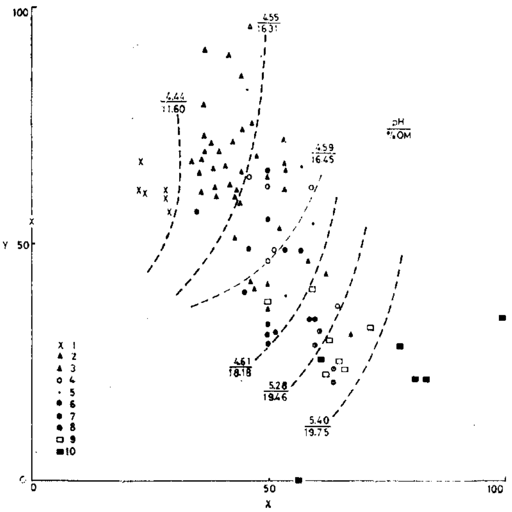

Fig. 3. Polar ordination of Y/X values of the 86 stands in Mt. Naejang. 1 : ***Pinus densiflora***, 2 : ***Quercus mongolica***, 3 : ***Quercus variabilis***, 4 : ***Carpinus laxiflora***, 5 : ***Daphniphyllum macropodum***, 6 : ***Carpinus tschonoskii***, 7 : ***Quercus aliena***, 8 : ***Torreya nucifera***, 9 : ***Cornus controversa-Lindera erythrocarpa***, 10 : ***Zelkova serrata*** stand.

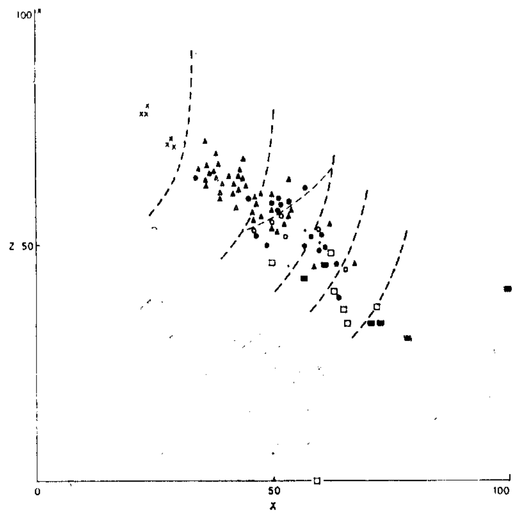

Fig. 4. Polar ordination of Z/X values of the 86 stands in Mt. Naejang. Symbols as in Fig. 3.

communities was showed a vegetational continuum. The distributions of soil pH and organic matter content were correlated to segments of the vegetational gredient (Fig. 3). It seems that moisture, pH and organic matter could be operated as a limiting factors to the distribution of species in this mountain as in Mt. Seonun (Kim and Yim, 1986).

Z/X ordination (Fig. 4) was also showed the same results as in Y/X ordination. However, the Z/X ordination brings out a more obvious separation and a more continuous connection of the ten communities. The Z/X ordination, therefore, may show the successional trends of total floristic variation among the communities.

The results of continuum analysis and polar ordinations for the forest vegetation were corresponded to those of phytosociological classification in classifying vegetation. Conseqeuntly, the two methods of ordination and classification can be used complementarily only where the degree of entitation and sampling intensity are the same.

摘 要

內藏山 國立公園의 森林植生을 Wisconsin 學派의 方法으로 分析하였던 바 그 結果가 前報의 環境傾度分析의 結果와 一致함을 發見하였다. 植生連續體分析에서 環境傾度分析에서와 같이 소나무 群集, 신갈나무 群集, 굴참나무 群集, 서어나무 群集, 개서어나무 群集, 비목나무 群集과 느티나무 群集이 連續指數의 傾度를 따라 順序的으로 配列되었다. Polar ordination에서도 同森林植生은 소나무 群集, 신갈나무 群集, 굴참나무 群集, 서어나무 群集, 굴거리나무 群集, 개서어나무 群集, 갈참나무—개서어나무 群集, 비자나무 群集, 층층나무

―비목나무 群集과 느티나무 群集의 10個 植物群集으로 分類할 수 있었으나 그들의 分布類型은 植生의 連續性을 보였다. 또 이러한 序列法에 의한 分析結果들은 植物社會學的 分類法에 의한 것과도 一致하였다.

LITERATURES CITED

Beals, E. (1960). Forest bird comminities in the Apostle islands of Wisconsin. Willson Bull., **72**: 156~181.

Bray, J.R. and J.T. Curtis. (1957). An ordination of the upland forest communities of southern Wisconsin. Ecol. Monogr., **27**: 325~349.

Broun, R.T. and J.T. Curtis. (1952). The upland conifer-hardwood forests of northern Wisconsin. Ecol. Monogr., **22**: 217~234.

Curtis, J.T. and R.P. McIntosh. (1951). An upland forest continuum in the prairie-forest border region Wisconsin. Ecol., **32**: 476~496.

Curtis, J.T. (1959). The vegetation of Wisconsin. Universty of Wisconsin press. Madison, 657p.

Kim, J.U. and Y.J. Yim. (1986). A gradient analysis of the mixed forest of Seonunsan area in southwestern Korea. Korean. J. Ecol., **9**: 225~230.

Kim, J.U. and Y.J. Yim. (1988a). Phytosociological classification of plant communities in Mt. Naejang, southwestern Korea. Korean. J. Bot., **31**: 1~31.

Kim, J.U. and Y.J. Yim. (1988b). Environmental gradient analyses of forest vegetation of Mt. Naejang, southwestern Korea. Korean J. Bot., **31**: 33~39.

McIntosh, R.P. (1967). The continuum concept of vegetation. Bot. Rev., **33**: 130~187.

Shimwell, D.W. (1971). The description and classification of vegetation. Univ. Washington Pre. Seattle, 322p.

Sørensen, T.A. (1948). A method of establishing groups of equal amplitude in plant sociology based on similarity of species content. K. Danske Vidensk Selsk. Biol. Skr., **5**: 1~34.

Whittaker, R.H. (1951). A criticism of the plant association and climatic climax concepts. Northwest Sci., **25**: 17~31.

Whittaker, R.H. (1956). Vegetation of the Great Smoky Mountains. Ecol. Monogr., **26**: 1~80.

(*Received 29 July 1988*)