

**ORIGINAL ARTICLE**

## Phytosociological Study and Spatial autocorrelation on the Forest Vegetation of Mt. Yeonae at Gijang-gun

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### Abstract

Mt. Yeonae is at Gijang-gun in Busan and is surrounded by farming lands on three sides. The search for the species composition and dynamics of local communities were studied at Mt. Yeonae of how spatial similarity decays with geographic distance. The index values of Zürich-Montpellier School's phytosociology at the 12 plots was compared to a distribution of similarly using 20 m quadrates at 12 sites. The specific communities were five including *Pinus densiflora* - *Quercus variabilis* community. Six species were significant similarity between neighboring sites by using the spatial autocorrelation coefficient, Moran's *I*. If Mt. Yeonae was destroyed by an artificial action, some spatial correlated species such as *P. densiflora* and *Q. variabilis* will be collapsed because of no maintaining the effective population sizes.

**Key words** : Mt. Yeonae, Species composition, Phytosociology, Spatial autocorrelation

### 1. Introduction

Community ecology is predicted on the notion that the fitness of individual organisms depends on their own identity in relation to the identities and abundances of other community members (Huh, 2011).

The search for patterns in the species composition and dynamics of local communities of interacting organisms, and for the processes that cause pattern, has seldom employed information about the phylogenetic relationships of species within those communities (Vane-Wright et al., 1991). Instead, species are usually treated as equivalent units, with independent functional traits (Roughgarden, 1989; Webb and Peart, 1999; Webb, 2000).

In this article, we describe general methods for quantifying the phylogenetic structure of local

communities of interacting organisms (relative to a shared species pool) and use data from a forest community in Mt. Yeonae (149.5 m) at Gijang-gun in Busan as an example of how this method can be used to address questions of community organization. Recently, the new road which is situated between Mt. Yeonae and Hoeryong-ri at Ilkweong-meon has been opened instead of old road. In addition, urban growth is gradually going on adjacent to Mt. Yeonae forest in Gijang-gun. Mt. Yeonae is surrounded by farming lands on three sides and the mountain is open towards the Hoeryong-ri in the northwest.

Urbanization adjacent to natural regions and forests often results in simplification of habitats and a community of plant, which lead to fewer species dominated by habitat patch size to species richness, increasement of immigration and extinction rates, and

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have been applied to habitat patch dynamics in fragmented urban areas (Soulé et al., 1988; Tilghman, 1987).

The spatial sampling was designed to detect spatial differences in the plant communities within the vicinity of the permanent stations (Sakai and Oden, 1983). These differences may be found as a higher similarity between the forest community at geographically closer sampling positions (spatial autocorrelation) or as larger scale gradients in the community composition mainly in N-S or W-E direction. To detect spatial autocorrelation in the species composition and community structure, a multivariate analysis was based on inter-sample similarities. In the presence of spatial autocorrelation, the similarity of samples taken closer together should be larger than the similarity of samples taken further apart.

We focused on the Mt. Yeonae of Southern part of Korea (Fig. 1). This mountain will be disappeared with the construction of the golf course after one or two years. We first derived testable predictions at Mt. Yeonae of how spatial similarity decays with geographic distance.

We asked the question, Are the plant species in local communities more or less related than expected if such communities were formed from a random sampling of available species in the larger area?

## 2. Materials and method

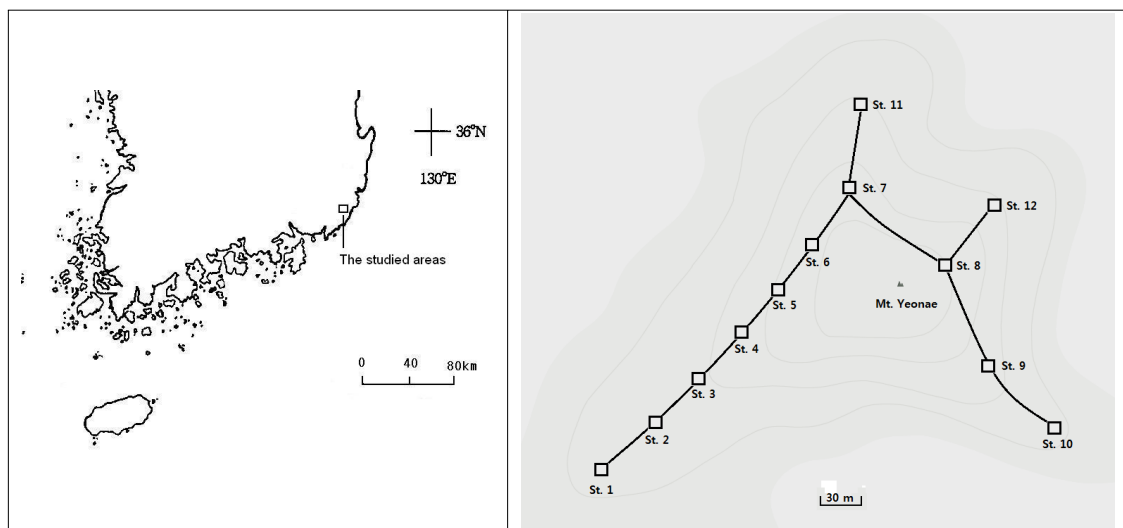
### 2.1. Study area

The data set consisted of trees and herb species sampled in 12 sites or plots (20 m x 20 m) in forest at Mt. Yeonae. The plots were scattered in a 50 m stratified sampling design and contained 49 species.

### 2.2. Phytosociology analysis

The index values of Zürich-Montpellier School's phytosociology at the 12 plots was compared to a distribution of similarly using 20 m quadrates at 12 sites. We calculated the same total number of plots in which a species occurred and the same total number of species within each particular plot as in the observed set. The main assumption implicit in this null model is that species have been able to disperse anywhere within the 12 sites.

Ecological flora data are based on site-releve



**Fig. 1.** Map of the study area and 12 collecting sites for spatial analysis.

matrix with relative net contribution degree (r-NCD) of species (1). A total of 49 species of vascular plants are recorded.

$$\begin{aligned} \text{NCDi} &= \sum C_i/N \times n_i/N \quad (C_{\min} \leq \text{NCD} \leq C_{\max}) \\ \text{r-NCDi} &= \text{NCDi}/\text{NCD}_{\max} \times 100 \end{aligned} \quad (1)$$

$C_i$  is the coverage of species and  $n_i$  is the proportion of all quadrates in a plot that belong to the  $i$ th species.

### 2.3. Analysis of spatial autocorrelation

The spatial structure of locus variations was quantified by Moran's  $I$ , a coefficient of spatial autocorrelation (SA) (Sokal and Oden, 1978a). As applied in this study, Moran's  $I$  quantifies the genetic similarity of pairs of spatially adjacent individuals relative to the population sample as a whole. The value of  $I$  ranges between +1 (completely positive autocorrelation, i.e., paired individuals have identical values) and -1 (completely negative autocorrelation). Each plant was assigned a value depending on the presence or absence of a specific allele.

Pairs of sampled individuals [total number of pairs:  $(49 \times 48)/2 = 1,076$ ] were classified according to the Euclidean distance,  $d_{ij}$ , so that class  $k$  included  $d_{ij}$  satisfying  $k - 1 < d_{ij} < k + 1$ , where  $k$  ranges from 1 to 12. The interval for each distance class was 50 ~ 70 m (the intervals between site 1 and site 7 were 50 ~ 55 m, the intervals between site 7 and site 12 were 60 ~ 70 m). Moran's  $I$  statistic for class  $k$  was calculated as follows (2):

$$I(k) = \frac{n \sum_i \sum_{j(i \neq j)} W_{ij} Z_i Z_j / S \sum_i Z_i^2}{(2)} \quad (2)$$

where  $Z_i$  is  $p_i - p$  ( $p$  is the average of  $p_i$ );  $W_{ij}$  is 1 if the distance between the  $i$ th and  $j$ th plants is classified into class  $k$ ; otherwise,  $W_{ij}$  is 0;  $n$  is the number of all samples and  $S$  is the sum of  $W_{ij}$   $\{\sum_i \sum_{j(i \neq j)} W_{ij}\}$  in class  $k$ . Under the randomization hypothesis,  $I(k)$  has the expected value  $u_1 = -1/(n - 1)$

for all  $k$ . Its variance,  $u_2$ , has been given, for example, in Sokal and Oden (1978b). Thus, if a species is randomly distributed for class  $k$ , the normalized  $I(k)$  for the standard normal deviation (SND) for the species,  $g(k) = \{I(k) - u_1\}/u_2^{1/2}$ , asymptotically has a standard normal distribution (Cliff and Ord, 1971). Hence, SND  $g(k)$  values exceeding 1.96, 2.58, and 3.27 are significant at the probability levels of 0.05, 0.01, and 0.001, respectively.

## 3. Results and Discussion

### 3.1. Phytosociological Study

3.1.1. *Pinus densiflora* - *Quercus variabilis* community  
Areas A and E were characterized by *Pinus densiflora* - *Quercus* community which were dominated by *P. densiflora*, *Q. variabilis*, *Q. aliena*, and *Q. serrata* (Table 1). Shrub layer of this community was represented the presence of the potential natural vegetation and subtropical-temperate plants which were composed of *Rhododendron mucronulatum* var. *ciliatum*, *Juniperus rigida*, *Prunus sargentii*, *Styrax japonica*, and *Smilax china*. This community was developed in the high frequency and coverage of evergreen broad-leaved species (Fujiwara, 1978; Miyawaki et al., 1994).

Herbaceous layer was the distribution of *Pteridium aquilinum* var. *latiusculum* and *Pyrola japonica* due to the relatively bright light environment. Community structure was formed of three-layer or incomplete four-layer structure.

*Pinus densiflora* at sites A was the dominant species in r-NCDi. The second and third dominant species in r-NCDi were *Q. variabilis* (91.3%) and *Rhododendron mucronulatum* var. *ciliatum* (73.9%), respectively. *Pinus densiflora* was the dominant species at sites E with 100% of r-NCDi. The next dominant species at tree layer were *Q. variabilis*, *Rhododendron mucronulatum* var. *ciliatum*, and *Rhus*

*tichocarpa*.

### 3.1.2. *Alnus firma* community

*Alnus firma* community at site B was the deciduous broad-leaved trees. This species was mainly introduced from Japan for the purpose of preventing sediment runoff in slope. Young trees of *Alnus firma* were planted on the north slope of the lower mountain about 43~45 years ago. The species was extended along the valley by dispersal of new generations after planting. The canopy was usually best developed where substantial amounts of light reach the woodland floor and composed with *Pinus densiflora*, *Pinus thunbergii*, *Quercus serrata*, *Quercus variabilis*, *Carpinus laxiflora*, and *Prunus sargentii*.

Shrub layer of this community was dominant in *Rhododendron mucronulatum* var. *ciliatum* with high frequency and coverage. *Styrax japonica*, *Rhus tichocarpa*, *Viburnum dilatatum*, and *Symplocos chinensis* var. *leucocarpa* for. *pilosa* were also found in this layer.

The herb layer of the forest is dominated by herbaceous (or soft-stemmed) plants such as *Polygonatum odoratum* var. *pluriflorum*, *Smilax china*, *Smilax china*, and other ground cover. Vegetation in the herb layer often gets little light and in forests with thick canopies, shade tolerant species are predominant in the herb layer.

*Alnus firma* was the dominant species at sites B with high r-NCDi (100%). The second dominant species in tree layer were *Pinus densiflora* (42.9%), *Carpinus laxiflora* (42.9%), and *Prunus sargentii* (42.9%).

### 3.1.3. *Pinus densiflora* - *Styrax japonica* community

*Pinus densiflora* - *Styrax japonica* community at site C was developed in the ridge part of Mt. Yeonae. The community was characterized by *Pinus densiflora*, *Styrax japonica*, *Q. variabilis* (Table 1). The community structure was formed of three-layer. Shrub layer was made up of young trees such as *Styrax japonica*, and smaller woody plants such as young *Prunus sargentii*,

*Rhus tichocarpa*, *Juniperus rigida*, *Zanthoxylum schinifolium*, and *Lindera erythrocarpa* that generally are only up to 4 m high.

Other plants such as *Viburnum wrightii*, *Ligustrum obtusifolium*, and *Stephanandra incisa* were also found here. These characteristic understorey trees sometimes have a sprawling sideways growth form.

*Pinus densiflora* was the dominant species at sites C and the value of r-NCDi was 100%. The second dominant species in r-NCDi was *Styrax japonica* (62.5%).

### 3.1.4. *Chamaecyparis obtusa* afforestation

*Chamaecyparis obtusa* was an evergreen conifer and developed on the eastern slope of Mt. Yeonae (Fig. 1). The canopy is *Chamaecyparis obtusa* where the crowns of most of the forest's trees meet and form a thick layer. The community structure was formed of three-layer. This shrub layer was shown by *Juniperus rigida*, *Zanthoxylum schinifolium*, and *Lindera erythrocarpa* in a clear area of the wood (Table 1). The herb layer was shown by *Carex siderosticta*, *Carex humilis* var. *nana*, *Pteridium aquilinum* var. *latiusculum*, and *Oplismenus undulatifolius*.

*Chamaecyparis obtusa* at sites D was the dominant species in r-NCDi. The second and third dominant species in r-NCDi were *Zanthoxylum schinifolium* (46.7%) and *Juniperus rigida* (40.0%), respectively.

### 3.1.5. *Quercus serrata* community

*Quercus serrata* community was developed on the eastern slope and formed on one side by a pine communities and agricultural development (Fig. 1). The plant communities are deciduous hardwoods. The community was characterized by *Pinus densiflora*, *Q. variabilis*, *Carpinus laxiflora*, *Lindera obtusiloba*, *Styrax japonica*, and *Rhus tichocarpa* (Table 1). The community structure was formed of three-layer. This shrub layer is mostly young trees growing in a clear area of the wood. The herb layer was shown by *Arundinella hirta*, *Smilax china*, and *Pteridium aquilinum*

Table 1. Structured table of forest vegetation in Mt. Yeonae

Running no.	1 2 3 4 5 6 7 8 9 10 11 12												Moran's I						
	YA-3 YA-4 YA-5 YA-6 YA-7 YA-8 YA-9 YA-10 YA-11 YA-12 YA-1 YA-2																		
Relevé no.	85 90 95 125 130 100 100 85 75 50 60 60																		
Altitude	W W W W W E E E E E E E E E E																		
Direction	W W W W W E E E E E E E E E E																		
Community type	A A B C D E F F F F F F F F F F																		
	A	B	C	D	E	F	A	B	C	D	E	F	I						
<b>Tree and shrub species</b>																			
<i>Pinus densiflora</i>	7	3	8	5	3	8	8	.	.	7	3	4	100.0	42.9	100.0	0	100	53.8	0.428***
<i>Quercus variabilis</i>	4	7	3	7	2	3	4	.	.	3	2	2	91.3	28.6	43.8	0	42.9	30.8	0.272*
<i>Carpinus laxiflora</i>	2	.	.	.	3	2	.	.	.	.	3	3	2.2	42.9	6.3	0	0	46.2	0.381**
<i>Quercus serrata</i>	4	5	.	3	2	.	2	.	.	2	7	6	39.1	28.6	6.3	0	28.6	100	0.423***
<i>Quercus dentata</i>	.	.	.	3	.	.	3	.	.	.	.	.	3.3	0	9.4	0	0.0	0	-0.131
<i>Quercus acutissima</i>	.	.	.	.	2	.	.	.	.	.	.	.	0.0	28.6	0.0	0	0.0	0	-0.080
<i>Quercus mongolica</i>	2	.	.	.	.	.	.	2	.	.	.	.	2.2	0	0.0	6.67	0.0	0	-0.269
<i>Quercus aliena</i>	2	.	.	.	.	2	1	2	.	.	2	.	2.2	0	6.3	6.67	0.0	7.69	-0.051
<i>Platycarya strovilacea</i>	.	.	.	.	.	2	.	.	.	.	.	.	0.0	0	6.3	0	0.0	0	-0.080
<i>Cryptomeria japonica</i>	.	.	.	.	.	.	.	.	.	.	.	.	0.0	0	0.0	0	0.0	7.69	-0.122
<i>Lindera obtusiloba</i>	.	3	.	.	.	.	.	.	.	.	.	.	3.3	0	0.0	0	0.0	0	-0.080
<i>Alnus firma</i>	3	.	.	.	7	2	.	.	.	.	3	3	3.3	100	6.3	0	0.0	46.2	-0.037
<i>Chaamaecyparis obtusa</i>	.	.	.	2	.	.	.	8	7	.	.	.	2.2	0	0.0	100	0.0	0	0.116
<i>Pinus rigida</i>	.	3	.	.	.	.	.	.	.	.	.	.	3.3	0	0.0	0	0.0	0	-0.080
<i>Pinus thunbergii</i>	2	.	.	.	2	.	2	.	.	2	.	.	2.2	28.6	6.3	0	28.6	0	-0.067
<i>Prunus sargentii</i>	2	3	.	3	3	2	2	2	2	2	2	2	26.1	42.9	25.0	6.67	28.6	30.8	-0.017
<i>Rhododendron mucronulatum</i> var. <i>ciliatum</i>	5	2	3	7	7	2	.	2	.	3	2	3	73.9	100	6.3	6.67	42.9	38.5	-0.318**
<i>Juniperus rigida</i>	2	3	2	1	.	2	.	3	3	.	2	2	34.8	0	6.3	40.0	0.0	30.8	-0.070
<i>Zanthoxylum schinifolium</i>	2	.	.	.	.	2	.	3	4	.	2	2	2.2	0	6.3	46.7	0.0	30.8	0.157
<i>Syrax japonica</i>	.	5	2	.	2	5	5	.	.	.	5	2	15.2	28.6	62.5	0	0.0	53.8	-0.076
<i>Rhus tichocarpa</i>	.	2	.	.	3	3	3	2	3	3	3	3	2.2	42.9	9.4	33.3	42.9	46.2	0.150
<i>Lindera erythrocarpa</i>	.	2	.	2	.	.	2	2	2	.	.	.	8.7	0	6.3	26.7	0.0	0	-0.131
<i>Aralia elata</i>	.	2	.	.	.	.	.	.	.	.	.	2	2.2	0	0.0	0	0.0	7.69	-0.177
<i>Eurya japonica</i>	.	.	.	2	.	.	.	.	.	1	1	.	2.2	0	0.0	0	14.3	3.85	0.088
<i>Viburnum dilatatum</i>	.	.	.	.	2	.	.	.	.	.	.	.	2.2	28.6	0.0	0	0	0	-0.080
<i>Symplocos chinensis</i> var. <i>leucocarpa</i> for. <i>pilosa</i>	.	.	.	.	2	.	.	.	.	.	.	.	0	28.6	0.0	0	0	0	-0.080

<i>Viburnum wrightii</i>	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	0	0	6.3	0	0	7.69	-0.223
<i>Ligustrum obtusifolium</i>	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	0	0	6.3	0	0	0	-0.080
<i>Stephanandra incisa</i>	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	0	0	6.3	0	0	0	-0.080
<i>Lindera glauca</i>	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	0	0	0	0	0	7.69	-0.122
<b>Companion species</b>																						
<i>Pyrola japonica</i>	2	.	.	.	.	.	1	2	.	.	.	.	2	.	.	2.2	14.3	6.3	0	28.6	0	-0.017
<i>Arundinella hirta</i>	1	.	1	.	.	.	1	.	1	.	.	.	1	1	1	4.3	0	3.1	3.33	0.0	15.4	-0.083
<i>Smilax china</i>	2	.	2	2	2	.	.	2	.	.	.	3	1	1	19.6	28.6	6.3	6.67	42.9	15.4	0.141	
<i>Disporum smilacinum</i>	2	1	.	.	.	.	.	1	1	.	.	.	1	.	6.5	0	12.5	0	14.3	3.85	0.142	
<i>Carex siderosticta</i>	.	.	.	2	2	1	1	2	1	.	.	.	1	.	2.2	28.6	12.5	20	0.0	3.85	0.152	
<i>Carex humilis</i> var. <i>nana</i>	.	1	.	.	.	.	.	.	1	2	3	.	.	.	1.1	0	0	0	20	42.9	0	0.321**
<i>Pteridium aquilinum</i> var. <i>latiusculum</i>	.	1	.	.	.	.	.	1	1	1	1	1	1	1	1.1	0	3.1	13.3	14.3	15.4	0.450***	
<i>Lonicera japonica</i>	.	.	1	.	.	.	.	.	.	.	.	.	.	.	1.1	0	0.0	0	0.0	3.85	0.054	
<i>Potentilla fragarioides</i> var. <i>major</i>	.	.	1	1	1	.	.	1	.	.	.	3	.	.	4.3	14.3	3.1	0	42.9	0	-0.107	
<i>Miscanthus sinensis</i> for. <i>purpurascens</i>	.	.	2	.	.	.	.	.	.	.	.	.	.	.	2.2	0	0.0	0	0.0	0	0	-0.080
<i>Sanguisorba hakusanensis</i>	.	.	.	.	.	.	1	.	.	.	.	1	.	.	0.0	14.3	0.0	0	14.3	0	-0.131	
<i>Isodon inflexus</i>	.	.	.	.	.	.	.	2	.	.	.	1	.	.	0.0	0	6.3	0	14.3	0	-0.129	
<i>Hosta longipes</i>	.	.	.	2	1	.	.	.	.	.	.	2	.	.	2.2	14.3	0.0	0	28.6	0	0.122	
<i>Artemisia keiskeana</i>	.	.	1	.	.	.	.	1	.	.	.	1	.	.	1.1	0	3.1	0	14.3	0	-0.090	
<i>Polygonatum odoratum</i> var. <i>pluiflorum</i>	.	.	1	1	3	.	.	.	.	.	.	.	.	.	4.3	42.9	0	0	0.0	0	0.207	
<i>Opismenus undulatifolius</i>	.	.	2	.	.	.	.	1	1	2	.	.	.	.	2.2	0	0	13.3	28.6	0	0.148	
<i>Syneilesis palmata</i>	1	1	.	.	.	.	.	.	.	.	.	.	.	.	19.6	28.6	0	0	0	0	0.069	
<i>Trachelospermum asiaticum</i>	.	.	.	.	1	.	.	.	.	.	.	.	.	.	1.1	0	0	0	0	0	0	-0.038
<i>Vitis thunbergii</i> var. <i>sinuata</i>	.	.	.	.	.	.	.	.	1	.	.	.	1	.	0	0	0	3.33	0	3.85	0.146	

\*  $p < 0.05$  \*\*  $p < 0.01$  \*\*\*  $p < 0.001$ .

var. *latiusculum*.

*Quercus serrata* at sites F was the dominant species in r-NCDi. The second dominant species in r-NCDi were *Pinus densiflora* (53.8%) and *Styrax japonica* (53.8%).

### 3.2. Spatial autocorrelation

Spatial autocorrelation analysis tests whether the observed value of physiognomy type at one locality is independent of the variables at neighboring localities. The spatial autocorrelation coefficient, Moran's *I*, for each class (site) is presented in Table 1. For physiognomy types, somewhat weak spatial autocorrelations were observed. Moran's *I* values deviated significantly from the expected value under the randomization assumption in 7 (14.3%) of 49 cases for vegetative characters. For *P. densiflora*, *Q. variabilis*, *Q. serrata*, *Carpinus laxiflora*, *Rhododendron mucronulatum* var. *ciliatum*, *Carex humilis* var. *nana*, and *Pteridium aquilinum* var. *latiusculum*, there were significant similarity between neighboring sites. For distance classes greater than 3, the six species except *Rhododendron mucronulatum* var. *ciliatum* were observed significant positive values, indicating an overall dissimilarity in vegetative types among pairs of sites in distance class 4 or greater than 3, i.e., pairs of sites separated by more than 150 m. *Rhododendron mucronulatum* var. *ciliatum* was observed significant

negative values in distance class 4 (200 m). The overall significance of individual correlograms was tested using Bonferroni's criteria (Sakai and Oden, 1983). The results revealed that genetic similarity was shared among individuals within up to a scale of a 50 m distance. The class interval of St. 7 and St. 8 was 70 m and showed structured community. Thus there were directly structured for the presence of phenetic correlations between neighbors at this scale.

For most species (32 species), there was significant heterogeneity of means with significant autocorrelation. There were negative values at distance class 1, indicating dissimilarity among pairs of populations in this distance class, but they were not significant.

As no significant correlation between the geographical distance and sampling positions can be found in 25 canopy and shrub species and 17 herb species, no spatial structuring of the forest community is detectable at the scale of the present sampling grain, interval and extend (Wiens, 1989). In addition, none of the correlograms for companion species indicated any statistically significant spatial altitude gradient. The results from this study are not consistent with the prediction that plant populations are subdivided into local demes or neighborhoods of related individuals (Ehrlich and Raven, 1969; Bradshaw, 1974). One possible explanation for the lack of spatial structure is that gene flow has been sufficiently extensive to

**Table 2.** Community similarities between the 12 sites at Mt. Yeonae

Site	1	2	3	4	5	6	7	8	9	10	11	12
1	-											
2	0.574	-										
3	0.709	0.505	-									
4	0.740	0.661	0.657	-								
5	0.684	0.413	0.451	0.592	-							
6	0.752	0.586	0.770	0.551	0.589	-						
7	0.654	0.612	0.678	0.583	0.434	0.739	-					
8	0.260	0.202	0.121	0.321	0.295	0.265	0.137	-				
9	0.150	0.022	0.123	0.202	0.110	0.233	0.079	0.844	-			
10	0.708	0.477	0.740	0.623	0.526	0.664	0.609	0.207	0.244	-		
11	0.667	0.680	0.412	0.478	0.601	0.667	0.583	0.292	0.223	0.457	-	
12	0.781	0.681	0.527	0.584	0.690	0.682	0.543	0.293	0.247	0.574	0.871	-

prevent the random divergence of local gene frequencies. Most correlograms show a positive correlation for the first class and a negative at class 2 (or 3). This may indicate a patch size of less than 100 m.

### 3.3. Site identity and cluster analysis

Site identity based on the proportion of shared species was used to evaluate relatedness among sites (Table 2). The estimate of values ranged from 0.079 (between St. 7 and St. 9) to 0.871 (between St. 11 and St. 12).

Clustering of sites, using the Neighboring-joining algorithm, was performed based on the matrix of calculated distances (Fig. 2). The phylogenetic tree showed three distinct clades. One includes *Pinus densiflora* - *Quercus* community, *Pinus densiflora* community, and *Quercus serrata* community. The other includes three communities, *Pinus densiflora* - *Quercus* community, *Alnus firma* community, and *Pinus densiflora* - *Styrax japonica* community. The last clade was *Chamaecyparis obtusa* afforestation.

## 4. Conclusion

Dramatic changes in ecosystems due to human activities lead to habitat degradation, fragmentation and consequent biodiversity loss (Laurance, 2007;

Wright and Muller-Landau, 2006). Habitat fragmentation involves alteration of habitat resulting in spatial separation of habitat units from a previous state of greater continuity. This phenomenon occurs naturally on a geologic time-scale or in unusual and catastrophic events. If Mt. Yeonae was destroyed by an artificial action, some spatial correlated species such as *P. densiflora*, *Q. variabilis*, *Q. serrata*, *Carpinus laxiflora*, *Rhododendron mucronulatum* var. *ciliatum*, *Carex humilis* var. *nana*, and *Pteridium aquilinum* var. *latiusculum* will be collapsed because of not maintaining the effective population sizes.

## 5. Conclusion

Mt. Yeonae were characterized by *Pinus densiflora* - *Quercus* community, *Alnus firma* community, *Pinus densiflora* - *Styrax japonica* community, *Chamaecyparis obtusa* afforestation, and *Quercus serrata* community. The forests were usually dominated by *P. densiflora*, *Q. variabilis*, *Q. aliena*, and *Q. serrata*. Six species including *Pinus densiflora* were significant similarity between neighboring sites by using the spatial autocorrelation coefficient, Moran's *I*. If Mt. Yeonae was destroyed by an artificial action, most community will be collapsed

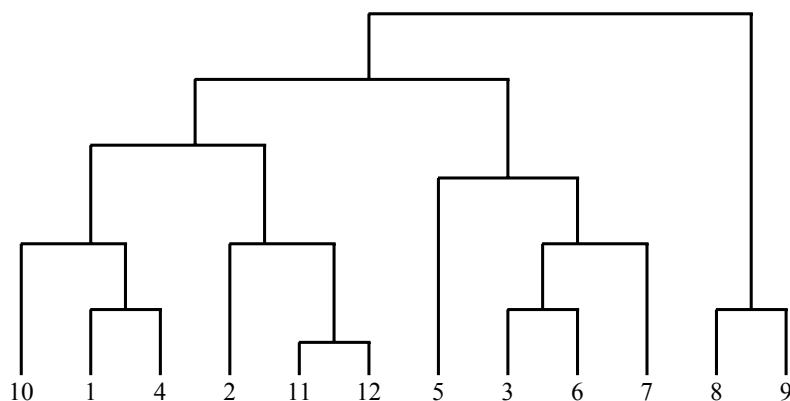


Fig. 2. Cluster analysis by Euclidean distance of 12 plant communities at Mt. Yeonae.



and species be disappeared. We suspect that comparisons of spatial autocorrelation between the plant species would be significant neighboring plants for effective population and would require an extensive canopy area than 200 m for the conservation strategy.

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