Plant Community and Species Distribution in Both Slopes of the Mt. Neungdong

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The purpose of the present investigation was to investigate diversity patterns in Mt. Neungdong forested landscape. It was conducted on twelve sloping plots (100×100 m) in the east and west sides of Mt. Neungdong. A total of 2,157 specimins were identified as trees with a diameter at breast height (DBH) ≥10 cm. There were a total of 135 species of 35 families present in both regions of Mt. Neungdong. Least significant differences (LSD) by post hoc analysis revealed that region A had significantly greater densities than region B. Shannon-Wiener functions differed significantly between forests (F=4.12, p<0.05), with region B forest having a significantly higher value (2.118) than region A (1.882). *Pinus thunbergii* and *Quercus aliena* were dominant on most plots of both regions, however, the *P. densiflora* forest of region A was distributed better in the middle plots exposures compared to the opposite ones. *Q. aliena, Q. mongolica,* and *Carpinus laxiflora* largely occupied the middle and lower exposures of region B. The spatial distribution in Neungdong's forest was very heterogeneous and reflected by most species as having micro-climate and patchy distributions.

Key words : Mt. Neungdong, least significant differences, Shannon-Wiener functions

Introduction

The correlation between vegetation and environmental parameters is one of the most fundamental questions contributing to understanding plant species composition and structure in a particular habitat, landscape and region [3,8]. Although plant communities are dynamics entities undergoing continuous change in response to climate, land use patterns and intrinsic dynamics within the communities, basic inventories provide a baseline against which changes can be determined [15].

Recently, the new road which is situated between Ulju-gun and Miryang-shi has been opened instead of old No. 24 National Road. In addition, the Mt. Neungdong is pierced by a tunnel. Understanding vegetation and environmental correlations at one point in time may be help to predict possible shifts attributed to climate and land use changes. In addition, urban growth is gradually going on adjacent to Seongnamsa (temple) and Ice Valley forest in Miryang-shi. Urbanization adjacent to natural regions and parks 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 have been applied to habitat patch dynamics in fragmented urban areas [10,11].

Forest losses across in Korea have led to declines in native plant species diversity and loss of habitat for numerous species.

The destruction and fragmentation of habitat results in the conservation of relatively continuous ecosystems, such as forests, into archipelago of natural habitat surrounded by a 'sea' of urban development [5].

The purpose of the present investigation was to investigate diversity patterns in Mt. Neungdong forested landscape. It was conducted on sloping twelve plots (100×100 m) that was representative of the two separated forests, where the canopy has well developed. What is the nature of floristic diversity and species richness patterns generally, and what are the effects of habitat fragmentation? The study was conducted to examine the relationship between floristic diversity patterns and plant life forms.

Materials and Methods

The Mt. Neungdong is located in the eastern of Miryang-shi and the western of Ulju-gun, Korea (35°38′26″N~35°38′27″N, 129°04′48″E~129°04′48″E) (Fig. 1). The mountain has a diversity of vegetation, most dominated by pine and oak trees. The mountain is situated on the south of the Mt. Gaji which has ca. 106.07 km^2. The topography is gently sloping in the lower and middle altitudes, and

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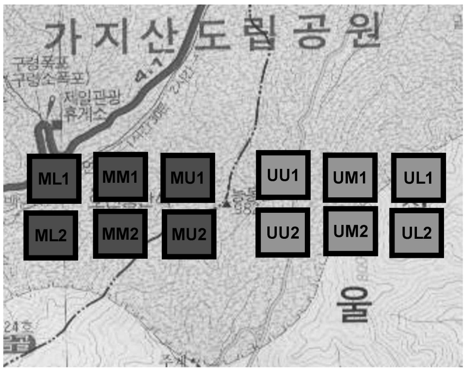

Fig. 1. Location of the regions at Mt. Neungdong and twelve sites used in this study. Region A: UU, UM, and UL mean upper, middle, and lower sites in the direction of Ulsan-shi, respectively. Region B: MU, MM, and ML mean upper, middle, and lower sites in the direction of Miryang-shi, respectively.

rather steep at higher altitude. The region B including the Hobakso on southeast Neungdong is a typically developed and truly old-growth evergreen broad-leaved forest.

These twelve sites had been selected to represent a valley slope geomorphic classification with similar elevation.

Within each forest region, six placed 100×100 m plots were set up on the plot with the most developed canopy and were completely censured for all trees with a diameter at breast height (DBH) $\geq$10 cm.

Analysis of variance and least significant differences post hoc tests were used with SYSTAT 9 to compare results between forest areas [9,16].

The Shannon-Weiner index of diversity was used to characterize species richness and abundance[3,14]. It was calculated as:

$$H' = -\sum_{i=1}^{s} (p_i)(\ln p_i)$$

Where s is the total number of species and p_i is the proportion of all individuals in a sample that belong to the ith species.

Species diversity may be thought as being composed of two components. The first is the number of species in the community, which ecologists often refer to as species richness. The second component is species evenness or equitability. Two well-known richness indices are as follows: R1 and R2 indices [7].

$$R1 = \frac{s-1}{\ln(n)}$$

$$R2 = \frac{s}{\sqrt{n}}$$

s: the total number of species in a community, n: the total number of individuals observed.

The common evenness indices used by ecologists are E1-E5 [2].

Jaccard's coefficient (J) of similarity for twelve 100 × 100 m plots was used to compare the number of species shared between plots in different shared regions.

J = number of shared species between plot A and plot B / number of species in plot A + number of species in plot B.

Environmental species and environmental plot relationships were investigated by detrended canonical correspondence analysis using CANOCO, version 4.0, based on normal data [12].

Results

Overall across the regions, total 2157 trees were identified and measured in the 100×100 m plots (Table 1). These were a total of 135 species and 35 families present in the two regions. Mean number of species per plot differed significantly between the two regions (F=6.22, $p<0.01$). Post hoc LSD tests showed that region A had a significantly greater mean number of species per region than region B. Mean number of families per region varied between 31 (region A) and 33 (region B), giving a total of 33 over all plots. Average density (tree per plot) differed significantly between regions (F=5.46, $p<0.001$). Least significant differences (LSD) post

Table 1. Richness and abundance parameters for 12 plots (100× 100 m) in two forest regions

		Region A	Region B	Total
No. of trees		1096	1061	2157
No. of species		92	112	135
No. of families		31	33	35
Mean no. of trees per plot		182.7	176.8	ns
Mean no. of species per plot		15.3	10.2	**
Mean no. of families per plot		5.2	5.5	ns
Shannon-Weiner index		1.882	2.118	*
Richness index	R1	2.214	2.709	**
	R2	0.931	1.133	*
Evenness index	E1	0.745	0.784	ns
	E2	0.531	0.563	ns
	E3	0.490	0.531	*
	E4	0.631	0.656	ns
	E5	0.563	0.607	**

* and **: Significant at the 0.05 and 0.01 levels, respectively.
ns: Nonsignificant.

hoc analysis revealed that regions A had significantly greater densities than region B. Shannon-Wiener functions differed significantly between forests (F=4.12, p<0.05), with region B forest having significantly higher value (2.118) than region A (1.822). The richness indices R1 and R2 decrease from region B to region A. Although the all evenness indices of region A was than those of region B, there did not show a significant differences.

A total of 17 species occurred at an abundance of 20 trees per plot or greater in at least one region, and ten species at an abundance of 40 trees per plot or greater, and two species at an abundance of 60 trees per plot or greater (Table 2).

Table 2. Major tree species exceeding 20 (+), 40 (++) and 60 (+++) individuals per plot in two forest regions

Species (Family)	Region A	Region B
Pinus densiflora Sieb. & Zucc. (Pinaceae)	+++	++
Pinus thunbergii Parlatore (Pinaceae)	+++	++
Quercus aliena Blume (Fagaceae)	+	+++
Quercus mongolica Fischer (Fagaceae)	+	+++
Quercus dentata Thunb. (Fagaceae)	+	++
Quercus variabilis BL. (Fagaceae)	+	++
Quercus acutissima Carruth. (Fagaceae)	+	++
Carpinus laxiflora BL. (Betulaceae)	+	++
Carpinus cordata Bl. (Betulaceae)	+	+
Sorbus commixta Hedl. (Rosaceae)	+	++
Prunus sargentii Rehder (Rosaceae)	+	+
Prunus yedoensis Matsumura (Rosaceae)	+	+
Cornus controversa Hemsl. (Coraceae)	+	++
Cornus walteri Wanger (Coraceae)	+	+
Robinia pseudo-acacia L. (Leguminosae)	+	
Chionanthus retusa Lindl. et Paxton (Oleaceae)		+
Fraxinus rhynchophylla Hance (Oleaceae)	+	+

Mean Jaccard's coefficient of similarity between regions pairs was compared by the two-sample t-test (Table 3). The Jaccard's coefficient showed two distinct groups, although UU1 and UU2 of region A and four middle and lower plots of region B were not well separated from each other.

Species abundance patterns in the two Neungdong regions mirror the right tail of a lognominal distribution, both for tree in the 100 × 100 m plots (Fig. 2). More than two-thirds of tree species and understory species of the two regions (A and B) are found in the first three abundance classes of the log-distribution (<20 years), while fewer than 6% were found in each of the final 12～15 abundance class. The distribution for all forests dramatically dropped off to a long right tail. However, 33% of the region B including the Hobakso Reserve is found in the final class of the log-distribution.

Two species were typical on almost all plots; *Pinus thunbergii* and *Quercus aliena*, thus they were the dominant habitat type on most plots. The most common species in the region A forest were *P. densiflora*, according for 35.4% of the individuals sampled in 100×100 m plots. The *P. densiflora* forest of region A is distributed better in the middle plots exposures compared with the opposite ones. *Q. aliena, Q. mongolica,* and *Carpinus laxiflora* largely occupied the middle and lower exposures of region B.

Restricting analysis gradually to higher dominant species, the dependency of species variance on environmental factors was still variances a little more (Fig. 2). When this study restricted the species to more than 5% in dominance (10 species), the first axis explained 12.8% of the species variation. *P. thunbergii* was dominant on most plots and they correlated with a combination of substrate variables, essentially

Table 3. Jaccard's coefficient of similarity (below diagonal) and t-tests (above diagonal) among 12 forest plots

Plot	UU1	UU2	UM1	UM2	UL1	UL2	MU1	MU2	MM1	MM2	ML1	ML
UU1	-	ns	ns	ns	ns	ns	ns	ns	*	*	**	**
UU2	0.998	-	ns	ns	ns	ns	*	*	*	*	*	*
UM1	0.991	0.994	-	ns	ns	ns	ns	ns	*	*	*	*
UM2	0.980	0.990	0.982	-	ns	ns	*	*	*	*	*	**
UL1	0.963	0.983	0.985	0.937	-	ns	**	**	**	**	***	**
UL2	0.969	0.977	0.977	0.943	0.995	-	***	**	***	**	**	***
MU1	0.950	0.891	0.906	0.890	0.764	0.771	-	ns	ns	ns	**	**
MU2	0.963	0.895	0.894	0.886	0.775	0.782	0.994	-	ns	ns	ns	*
MM1	0.848	0.872	0.881	0.874	0.776	0.755	0.992	0.989	-	ns	ns	*
MM2	0.859	0.896	0.858	0.877	0.784	0.789	0.978	0.983	0.991	-	*	*
ML1	0.802	0.869	0.862	0.823	0.772	0.766	0.880	0.977	0.923	0.918	-	ns
ML2	0.813	0.870	0.870	0.798	0.795	0.773	0.834	0.886	0.884	0.876	0.985	-

Asterisks and ns are the same as Table 1. ***: Significant at the 0.001 level.

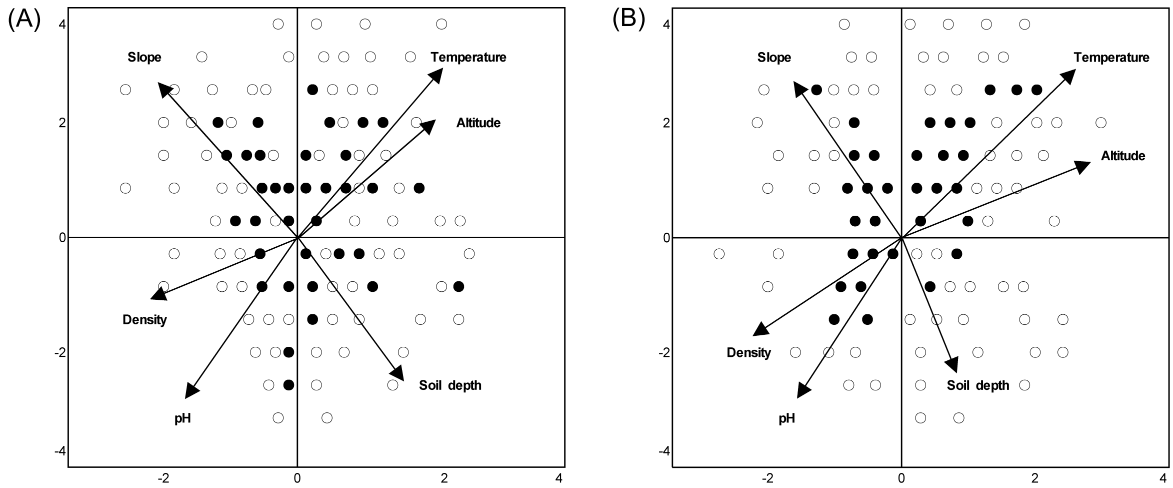

Fig. 2. Detrended canonical correspondence analysis coordination diagram showing understory species scores (○) and plot scores (●) by basal regions A (A) and B (B).

presenting level temperature and slopes, while *Q. aliena, Q. mongolica,* and *C. laxiflora* appeared to be linked to communities in lower altitude on moderate slopes.

Discussion

Environmental heterogeneity has an important influence on the development of plant community. Numerous researches have proposed a positive correlation between environmental variability and species richness [4]. The distribution of plant communities in the Mt. Neungdong reflects the combined influence of altitude, topology and micro-temperature, a patterns observed in many mountain areas [13]. In a broader context these patterns can be considered a combination of factors operating at different scales. Regional parameters such as climatic and associated floristic regions provide the species matrix for a particular area [6]. Landscape parameters, for example altitude sorting vegetation composition along with a local climatic gradient, further redefine vegetation patterns. Microhabitats and tiny Föhn wind conditions provide the final separation into local plant communities. Föhn wind is a type of dry down slope wind which occurs in the lee of a mountain range (region A). Region A shows a warmer climate due to the Föhn and region B. Thus, cold region B and circumferences are suitable candidates for apple cultivation and famous for "Eoreumgol-apple".

In this study, tree density and soil pH per plot were not related directly to estimates of recruitment for several tree species. However, smaller habitat that is consisted of a greater proportion of edge habitat that is unsuitable for out-crossing mating system species than inbreeding species and high density in a area [1]. Accurately determining the distance into forests that is unsuitable for all species is not yet possible and would require better projections for populations using measures of mortality and survivorship over multiple years. Still, these is a marked reduction in recruitment at site near edges. For example, although fragments are usually not square-shaped, two 100×100 m plots for each plot is more diversity than four 100×100 m plots for each region.

A total of 68 tree species occurred at an abundance of fifteen in at least one fragments (Table 1). Among understory species, 33 species were found at abundance of 87 individuals or more (data not shown).

Considering just the most common species, the community comparison of the fragments is strikingly different (Fig. 2). The region A is primarily a *P. thunbergii - Q. aliena* forest, whereas the region B is all dominant by *Q. aliena - C. laxiflora.*

The spatial distribution in southern Neungdong's littoral forest in very heterogeneous, reflected by most species having low densities and patchy distributions. In addition there were significant differences between the two forest regions in this study in terms of Shannon-Weiner index of diversity, number of trees, species richness, family richness, species evenness and species composition.

References

1. Aizen, M. A. and P. Feinsinger. 1994. Forest fragmentation,

pollination, and plant reproduction in Chago dry forest. Argentina. *Ecology* **75**, 330-351.
2. Alataro, R. V., A. Lundberg, and K. Stahlbrandt. 1982. Why do pied fly catcher females mate with already-mated males? *Anim. Behav.* **30**, 585-593.
3. Barbour, M. G., J. H. Burk, W. D. Pitts, F. S. Gilliam, and M. W. Schwartz. 1999. Terrestial Plant Ecology. Benjamin/Cummings, Don Mills, Ontario.
4. Campbell, B. D. and J. P. Grime. 1989. A comparative study of plant responsiveness to the duration of episodes of mineral nutrient enrichment. *New Phytol.* **112**, 261-267.
5. Harada, K. 2003. Attitude of local people towards conservation and Gunung Halimun National Park in West Java, Indonesia. *J. For. Res.* **8**, 271-282.
6. Hobbs, R. J. and V. A. Cramer. 2003. Natural ecosystem: Pattern and process in relation to local and landscape diversity in southwestern Australian woodlands. *Plant and Soil* **257**, 371-378.
7. Margalef, R. 1958. Information theory in ecology. *Gen. Syst.* **3**, 36-71.
8. Mucina, L. 1997. Classification of vegetation: Past, present and future. *J. Veg. Sci.* **8**, 751-760.
9. Slius, W. J. 2002. Patterns of species richness and composition in recreated grassland. *Rest. Ecol.* **10**, 677-684.
10. Soulé, M. E., D. T. Bolger, and A. C. Alberts. 1988. Reconstructed dynamics of urban habitat islands. *Conser. Biol.* **2**, 75-91.
11. Tilghman, N. G. 1987. Characteristics of urban woodlands affecting breeding bird diversity and abundance. *Land & Urban Plan.* **14**, 481-495.
12. ter Braak C. J. and P. Smilauer. 1998. Software for Vanonical Community Ordination (Ver. 4). Microcomputer Power: Ithaca, NY.
13. Toth, L. A. 2005. Plant community structure and temporal variability in a channelized subtropical flood plain. *Southeastern Natl.* **4**, 393-408.
14. Weaver, M. and M. Kellman. 1981. The effects of forest fragmentation on woodland tree biotas in Southern Ontario. *J. Biogeography* **8**, 199-210.
15. Young, T. P. 2000. Restoration ecology and conservation biology. *Biol. Conser.* **92**, 73-83.
16. Zar, J. H. 1984. *Biostatistical Analysis.* 2nd eds., Prentice-Hall. Englewood Cliffs, NJ.

초록 : 능동산의 양사면에서 식물 군락과 종 분포

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본 조사는 능동산의 산림지 2곳에 대한 목본류의 다양성 양상을 조사하기 위해 12 plot (100×100 m)를 설정하였다. 흉고직경 10 cm 이상의 목본류 2,157 그루를 동정한 결과 총 35과 135종이었다. 최소 유의성 차이(LSD)에서 지역 A (울주군 석남사 방향)가 지역 B (밀양시 얼음골 방향)보다 높았다. Shannon-Wiener의 다양성 지수에서 지역 A는 1.822, 지역 B는 2.118로 두 지역간 유의한 차이가 있었다($F=4.12$, $p<0.05$). 곰솔-갈참나무군락이 두 지역에서 우점 하였다. 그러나 지역 A의 중간 고도는 소나무가 우점인 반면 지역 B의 중간 고도부위는 참나무속 식물군락과 서어나무군락이 우점 하였다. 공간 분포 분석에서 능동산의 동서지역의 식물상은 서로 이질적이며 미세기후와 패치(patchy)구조를 나타내었다.