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Landscape Ecological Studies on Structure and Dynamics of Plant Populations on Vegetation-Landscape Patterns in Rural Regions: I. The Effect of Patch Shape on the Initial Population Structure of Pine and Oaks

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ABSTRACT: Secondary vegetation, the holistically integrated system of nature and human being, is the complicated ecosystem that is composed of natural and man-created factors. Understanding the ecological function of secondary vegetation supplies us many important informations for sustainable landscape management and ecological restoration planning. In this research, we tried to examine the shape effect of vegetation patch on early structure of populations of pine and oaks. Moreover, we also tried to clarify the ecological functions of patch edge by exploring the patch effect on germination using patch index. In addition, we present the landscape structure of man-made vegetation of our study area, and setting experimental design of research. Vegetation landscape of study area is typical human disturbed landscape mainly composed of disturbance patches. Vegetation types of graveyard and managed pine forest were controlled by periodically repeated management. However, current seedlings of pine occurred well at both vegetation types. Presence of both saplings were more controlled in managed pine forest (PDM) and graveyard (G) than those of undergrowth (PD) and forest edge (FE) with canopy trees. The number of pine seedlings increased with patch size and patch perimeter. That of oak seedlings was, however, not significantly different. Larger graveyards provided higher light availability for germination of pine seedlings. We think, however, most seedlings of both species in the large sized graveyards without shade will die more easily than that of small sized ones before rainy summer. Relationships between patch shape and germination of two woody species cannot be exactly explained enough yet in these results. More informations on spatial interaction of the total species with differently sized patches are necessary to solve the concept of patch effect on species colonization.

Key Words: Graveyard, Fractal geometry, Patch shape, Pine forest, Population structure, Rural landscape, Vegetation type.

INTRODUCTION

Rural forest as secondary vegetation of landscape element in East Asia is the special sustained vegetation by human activity and has been used for sustainable supplies of biomass as energy and green fertilizer to near village (Kamada and Nakagoshi 1991, Hong and Nakagoshi 1996, 1998b). Rural forest, therefore, has a distinct vegetation type and biodiversity different from natural one in accordance with different intensity of landscape management (Iida and Nakashizuka 1995, Hong 1998).

Forests with mosaic vegetation types have specialized in the functioning ecosystem processes different from climax forest (Fowler 1988, Verboom and van Apeldoorn 1990, Fitzgibbon 1997, Hong and Rim 1997, Tamura 1998). These vegetation types, however, have been disappeared owing to abandonment of vegetation management accompanied by the changes of rural energy and fertilizer by recent economic development (Hong *et al.* 1993, 1995).

Therefore, agricultural landscape system including these secondary vegetations is faced to the ecological high-risk related with total environmental problems such as loss of habitat, decreasing biodiversity, soil pollution by excessive chemical fertilizer and other human activities on the land (Iida and Nakashizuka 1995). These spatiotemporally complicated problems are simultaneously occurring between (among) several ecosystems, not a single ecosystem, in a different scale (Haber 1990, Naveh 1994, Hong and

Lee 1997).

To understand the ecosystem function and contribution of current rural forest to the conservation of ecological characteristics, landscape ecological principles treating holistic human-nature system and spatially complexed ecosystems at the different scales need to be considered in the domain of study field (Arnold 1995, Kirby 1996).

Under the idea of conservation and ecological restoration of rural forest, this study was planned. Landscape ecological study is focusing on structure, function and changes (dynamics) of a landscape and ecosystems at the spatial scale (Forman and Godron 1986). These three approaches are characterized in a mosaic landscape composed of heterogeneous patches, and many ecological processes also addressed in relationships between spatial and temporal pattern of the patches (Forman 1995, Wiens 1995).

For landscape evaluation, planning, environmental management and restoration, there were several case studies on rural landscapes with a view of broad-scaled structure of landscape under different disturbance regimes (e.g. Hong *et al.* 1995, Hong 1998, 1999, Lee and Hong 1998). In a view of fine-scale and coarse-scale landscape (Forman 1995), however, a few case about ecological characteristics and functions among (or between) elements such as patch, matrix and edge composing a landscape mosaic was carried out (i.e. Hong and Rim 1997, Lee *et al.* 1998). Ecological characteristics and origin of patch as landscape compositions are influenced from natural and human disturbances (Forman and Godron 1986). Moreover, pattern, shape and orientation of landscape components according to natural and human disturbances influence on the animal and plant population movements and mass flow, and then turnover rate of dynamic landscape. Examining patch characteristics is therefore to verify the state of the art of disturbance on the landscape appearing patch type and shape (Forman 1995).

In this study, we examine the shape effect of landscape patch and edge on ecological processes of population structure and dynamics. We also clarify the ecological function of edge between the adjacent patches. Firstly, in this paper, we present the landscape structure of the study area in a fine-scale map and examined the early population structure of co-occurring pine and oak by preliminary data. Secondly, using several patch shape indices based on fractal model (O'Neill 1988, Milne 1991), we try to clarify the effect of disturbance intensity on the mosaic vegetation types characterizing rural vegetation.

MATERIALS AND METHODS

Study area

This study was carried out in Yanghwa-ri (lat. 36° 23' N, long. 127° 12' E), Kyeryongmyon in Chung cheongnam-do. The vegetation of the study area has been described in the previous studies (Hong *et al.* 1993, Hong and Nakagoshi 1996). The secondary pine (*Pinus densiflora*) forest covers two sites. Yanghwa-ri is a hamlet in Mt. Kyeryong National Park, so that people can easily access to the village. The soil is derived from granite of base rock and most forest areas of Yanghwa-ri are privately owned.

The vegetation in the area is a secondary vegetation mostly composed of *Pinus densiflora* and several deciduous oak species. Vegetations near village are mixed with deciduous oak forests such as *Quercus acutissima* and *Q. mongolica* and pine forests.

Mountain vegetation far from villages is characterized by *Pinus densiflora-Quercus mongolica* community (Song and Shin 1985). Annual mean temperature and precipitation are 12.2℃ and 1,319 mm, respectively, though there is annual difference in the monthly mean precipitation.

Landscape analysis of vegetation patch

We carefully selected the vegetation landscape composing mosaic vegetation types. A fine-scaled vegetation mapping of the selected vegetation landscape was carried out on the topographic map (a scale of 1:5,000) through direct survey (Fig. 1). Boundary of patches is identified by physiognomic difference of vegetation types (Hong 1998). Size and shape of vegetation types including cultural elements (e.g. graveyard) were considered as the indicator of anthropogenic disturbance factors in the region (Forman 1995, Hong 1998). Therefore, vegetation mapping was carefully carried out with consideration of those factors.

Using an area-curvimeter (X-PLAN 360KII+, Ushikata Inc.), area and perimeter of each patch were measured. Patch number was also counted. For all landscape patch, to quantify the disturbance intensity on patch boundary and evaluate the amount of edges, an index of the shape of patch edge (D, shoreline development, Patton's diversity index) based on area and perimeter of the patch was introduced. The equation is as follows:

$$D = P/2\sqrt{\pi A}$$

where P is perimeter length and A is area of the patch. The circle has an index near 1.0, and it becomes larger with many irregularities and convolution of patch boundary (Forman 1995).

Especially in graveyard among landscape patches, to demonstrate the shape effect of vegetation patches on population structure in the early stage of vegetation process, a measurement of fractal geometry (i.e. fractal dimension, *FD*) of graveyards was analyzed. The equation is as follows:

$$FD = 2xa$$

where *a* is regression slope between area and perimeter of a patch. For simple polygons (patch) such as circle and rectangles, the value of *FD* approaches 1.0. For irregular and complex polygons the perimeter tends to fill the plane with high *FD* approaching 2.0 (O'Neill *et al.* 1988, Milne 1991, Farina 1998). In the present paper, for graveyard, patch circularity (cf. Forman 1995) that explaining convolution of patch edge was corresponded to shoreline development index (*D*).

Experimental design

Two experimental settings were designed. The first design is as follows. Five study plots composed of several vegetation types were selected (Fig. 1). Study plot was divided into four different vegetation types: the pine forest with unexploited undergrowth (PD), the pine forest without undergrowth by management (PDM), an open space including graveyard (G) and forest edge (FE) between PDM and G. Ten $1 \times 1\,m^2$ permanent quadrats were set up in each of the five plots, and a preliminary survey including tree census for all woody stems had been carried out in surrounding quadrats.

Current seedlings (first-year seedlings) and saplings of the pine and oaks were counted in these subplots since April 1998. Presence and absence of seedlings and saplings of the pine and oaks were recorded by every mid-month. Seedlings and established saplings were marked on the meshed map for checking their survival (Hong and Nakagoshi 1998a). Ages of pine and oak saplings were counted by terminal bud scale scars. Individuals over two years old were treated as saplings. Juveniles smaller than 1.0 m in height were also considered as saplings. We counted the mean number of the sound seedlings for three months, and saplings per ten quadrats of each vegetation type were applied to statistical analysis. In the present paper, the early germinated seedlings observed during early April to June 1998 were used for statistical analysis.

The second experiment was carried out in all graveyards (G) in the landscape. Current seedlings were cross-checked in all graveyards with a line transect method by distance of 5 m. All woody seedlings were counted in a temporary quadrat ($1 \times 1\,m^2$) in the line transect. Mean number of observed seedlings corresponded to area, perimeter of patch, shoreline (i.e. patch edge) development index (*D*) of each graveyard based on the two measurements.

Environmental analysis

Three environmental variables of the site condition were used in this study. Organic carbon of soil was determined by loss-on-ignition, and total nitrogen content was determined by the micro-Kjeldahl method. Total nitrogen and carbon content were determined by C/N coder. In this study, carbon was considered as organic carbon because of the acidic soil property of pine forests in Yanghwa-ri. The soil pH was also measured using a glass electrode assembly.

The relative light intensities of the subplots were measured by using hemispherical photograph taken with fisheye lens (Hong and Nakagoshi 1998a) at the height of 30-cm from the floor with a tripod. The percentage reduction of illuminance was estimated by counting the clear and obstructed segments using a special grid. Environmental data referred in the previous studies at the same area (Hong *et al.* 1993, Hong and Nakagoshi 1998a) was adapted to this study.

Vegetation survey surrounding permanent quadrat was carried out. Coverage of each vegetation layer (Braun-Blanquet 1964) was recorded. The cover (percentage) of litter of each subplot was also measured. Total plant species identified in the stands were placed in life-form such as woody, herb, and evergreen plant classes.

Data analysis

Differences among sampling data, vegetation types and vegetation patch parameters were analyzed through ANOVA (Zar 1974). Fisher's PLSD (protected least significant difference) test was used to check for significant difference, with $p < 0.05$ used to denote significance. Data were analyzed with statistic-graphic software StatView (StatView ver. 4.02, Abacus Concepts, Inc. 1992).

RESULTS AND DISCUSSION

Landscape pattern and characteristics of patches

A patch is defined as "a non-linear surface area differing in appearance from its surroundings" (Forman and Godron 1986, Hong and Lee

Table 1. Configuration of landscape structure of study area and measurements of patch characteristics of each patch composing the landscape.

Landscape element	Area (m^2)		%(1)	Perimeter (m)		No. Patch	%(2)	Median Patch shape§
	Sum	Mean (±S.E.)		Sum	Mean (±S.E.)			
Vegetation attribute	16420	-	2.9	638		1	1.3	1.404
Pine-Oak mixed forest (PQ)	164020	32876.0(16976.3)	28.8	7184	1436.8(654.1)	5	6.4	1.298
Pinus densiflora forest (PDM)	76690	8521.1(3262.1)	13.5	5121	569.0(122.3)	9	11.8	1.820
Quercus acutissima forest (Qa)	15240	2540.0(794.0)	2.7	1304	217.3(29.1)	6	7.8	1.220
Subtotal	272370		47.9			21	27.3	
Cultural attribute								
Rice field (RF)	55000	6875.0(1822.5)	9.6	3242	405.2(65.5)	8	10.5	1.413
Plowing field (RF)	99930	12491.2(5636.7)	17.6	5994	7489.2(212.7)	8	10.5	1.663
Castanea crenata orchard (O)	21100	-	3.7	935	-	1	1.3	*1.815
Bamboo plantation (B)	1400	-	0.2	162	-	1	1.3	*1.221
Abandoned field (AF)	23630	-	4.1	1045	-	1	1.3	*1.918
Graveyard (G)	48740	1805.1(275.2)	8.5	4657	172.4(16.2)	27	35.0	1.142
Subtotal	249800		43.7			46	59.9	
Other land-use								
Inhabited and Exploited area (IE)	45360	6051.4(3151.8)	7.5	7.5	299.8(94.5)	7	9.0	1.268
Road (R)	5470	1823.3(365.2)	0.9	0.9	384.6(79.4)	3	3.8	1.769
Total	570000		100	100		77	100	

(1); a percentage of certain element per total area, (2); a percentage of certain patch number per total number of patch. §; shape index of a patch (D, Patton's diversity), *One sample patch, median value was not calculated. This shows a mean value.

1997). Normally, patches in a vegetation pattern are plant communities, i.e. assemblages of species. Phytosociological vegetation unit is not patch. Landscape is consisted by vegetation type in kind/character and by patch of different structural subordered vegetation unit and land use type. Patch is a real stand identified to each vegetation type and land use type(N. Nakagoshi pers. comm.). Type of patch is determined by origin and causative mechanism of spatiotemporal disturbance and its intensity on landscape or ecosystems. According to Forman (1995), vegetation landscape is composed of disturbance patch, remnant patch, introduced patch and environmental resource patch. Except for environmental resource patch, three patches often showing susceptibility against disturbance are defined in the study area. It is very similar to other landscape systems mainly composed of secondary vegetation (Hong *et al.* 1995, Hong 1998, Hong and Rim 1998, Hong 1999).

Total twelve landscape elements were counted, and less than 50% of the area was covered with vegetation element in the landscape (Table 1). Area of pine-oak mixed forest (PQ) as a remnant vegetation patch from human disturbance patches (e.g., PD, PDM and cultural element) was 2.9% of total area. PQ has only one isolated patch from similar vegetation types, and therefore, this patch type can be transformed into oak forest as far as human activity crases. PD and PDM of disturbance patch were major vegetation elements, and they have a large proportion of coverage of the landscape. Especially PD has a mixed configuation of introduced patch and disturbace one originated from human disrbance such as plantation, and therefore edge effect of the patch was apparent in the area-erimeter ratio (D=1.298). PDM is also disturbance patch under chronic disturbance on the forest and, consequently, composed of tall trees of *Pinus densiflora* with few understories (Table 2). High value of areaperimeter ratio indicates highly convoluted shape by occupying graveyards (D=1.820). *Quercus acutissima* (QA) is an originally natural patch in the village. We think they extended to near disturbed area with other *Quercus* spp. for use of fuel material. QA patch, therefore, was distributed near village. *Castanea crenata* (O) and bamboo forest (B) supply traditional food as *Q. acutissima*. These landscape elements often occurred between hamlet and other main secondary vegetation, i.e. *Pinus densiflora* and *Quercus mongolica* community with a small patchy mosaic pattern (Hong 1999).

Rice field (RF) and plowing field (PF) were major landscape patches as cultural element (9.6 and 17.6% of total area, respectively). While the area of PF was larger than that of rice successional species (i.e. herbaceous plants) often colonize from outer boundary (edge) to inner part of patch (Forman 1995). These ecological processes make patch boundary to develop. In the case of vegetation, roadside vegetation such as saum and mantle communities (Forman and Godron 1986) occurred in the boundary of forest patch. However, this AF is young and few woody species were invaded.

Vegetation landscape was fragmented and occupied by many graveyards (Fig. 1). Graveyard is very simple shape because of the high intensity of human disturbance on surrounding of graveyard (D=1.142). The total landscape system of the study area is influenced by anthropogenic disturbance regimes (especially repeated and periodic disturbance) such as managing graveyard and agriculture.

From Figure 1, we could simply demonstrate the total landscape pattern of the study area in accordance with distance from the road: Road ⇒ Rice (=paddy) field ⇒ Plowing(=dry) field ⇒ Farm house ⇒ Orchard (including Bamboo plantation) ⇒ Graveyard ⇒ Managed forest (*Pinus densiflora, Quercus acutissima*, etc.) ⇒ Plantations (*Pinus rigida*, etc.) ⇒ Natural vegetation (*P. densiflora, Quercus* spp, mixed forests). This type of landscape pattern is generally similar to other agricultural landscape systems in Korea (Hong 1999) although the pattern and extent of patch component, especially in mountain landscape, become slightly different with altitude (Hong and Rim 1998).

Spatial characteristics of graveyard as an indicator of human disturbance

Graveyards (G) of various sizes were found in the study area (Fig. 2-A, B). However, most were small, less than 2,000 m^2 composed of two or three mounds (Fig. 2-B). Large sized graveyard more than 5,000 m^2 was found, but it was not the usual size in the region. Their shape was generally similar to each other (Fig. 2-C, approx. 70% of D: 1.01~1.25). Area of each graveyard was highly significantly correlated with the perimeter (r^2=0.979, $p<0.001$). Moreover, borderline complexity of graveyard was more or less near 1.0 (Fractal dimension=1.232). Fractal dimensions of patch and edge have implications for many ecological processes and resources related to human system on landscape (O'Neill *et al.* 1988, Hong and Rim 1998).

According to Turner and Ruscher (1988), total fractal dimension of landscape patterns in Georgia, USA, is decreased by land transition and development for 50 years. Comparing secondary field in this result, major cultural landscape element is rice field in the Yanghwa-ri (Hong

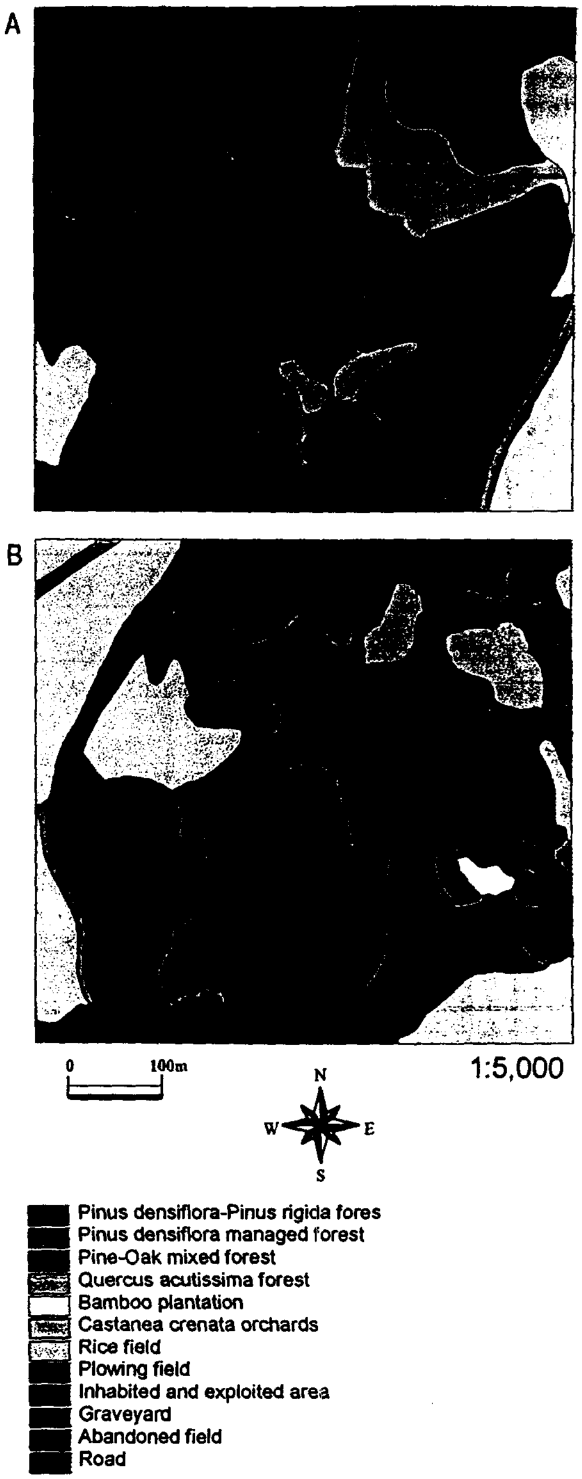

Fig. 1. Maps of vegetation-landscape in Yanghwa-ri. Both areas (A, B) are neighboring each other by 100-m distance. In this study, we regard these two area as the same area influenced from the human disturbance concurrently. Boundary means vegetation-landscape patches and its boundary: *Pinus densiflora-P. rigida* forest (PD), *Pinus densiflora* managed forest (PDM), Pine-Oak mixed forest (PQ), *Quercus acutissima* forest (Qa), Bamboo plantation (B), *Castanea crenata* orchard (O), Rice(=paddy) field (RF), Plowing (=dry) field (PF), Inhabited and exploited area (IE), Graveyard (G), Abandoned field (AF), Road (R).

et al. 1995). Abandoned field (AF) under vegetation succession shows the highest value of area-perimeter ratio (D=1.918). In natural ecosystems, when a patch is disturbed, the early vegetation in different landscape system, vegetation succession process is dependent on patch shape with different intensity of disturbance (Hong 1998). In the study, shape index (D) and fractal geometry (FD) indicate the intensity of disturbance on patch and boundary (edge). Low fractal dimension and shape index means landscape management on graveyard is focusing on its shape, and its intensity is chronic (repeated) and periodical.

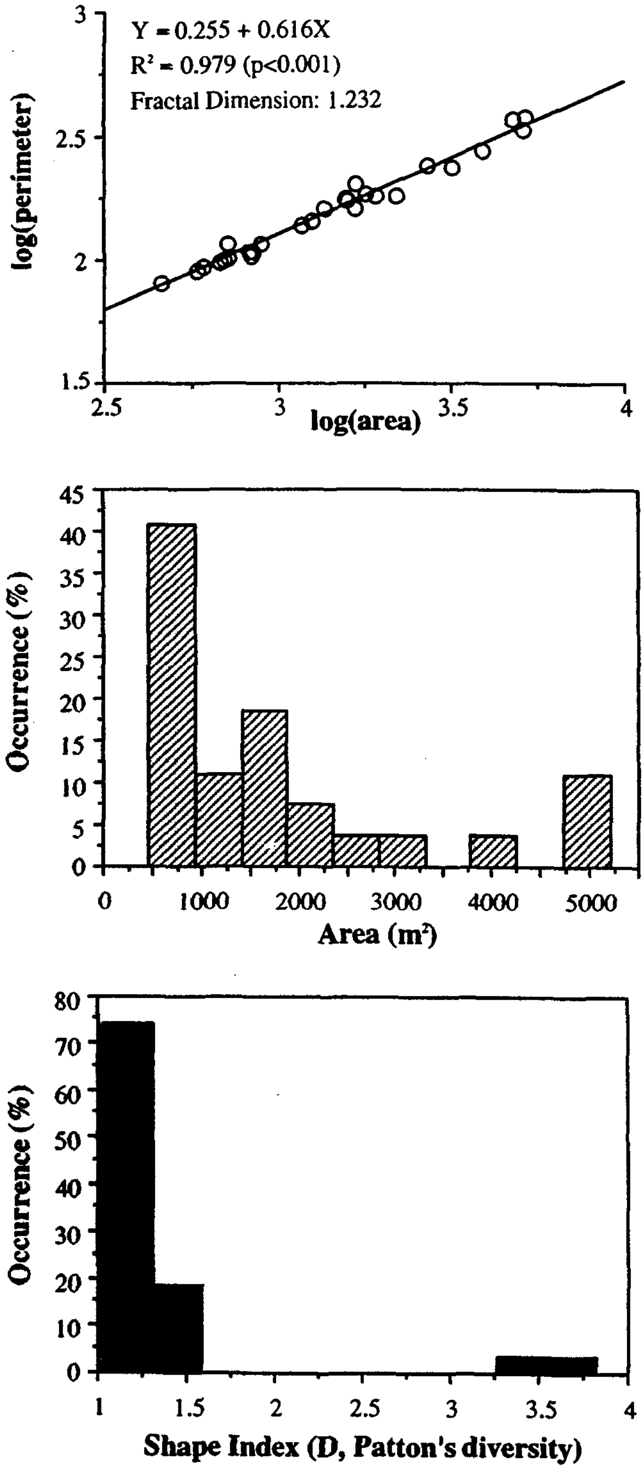

Fig. 2. Shape characteristics of graveyard in the study area. A: Relationship between perimeter length and area of graveyard, B: Occurrence frequency of graveyard by area, C: Occurrence frequency of graveyard by boundary development index (D, Patton's diversity).

Initial population structure of pine and oak in different vegetation types

Successful germination and initial growth of plants are significantly related to environmental variables such as light and soil moisture (Grime 1979, Canham *et al.* 1990, Lorimer *et al.* 1994). These variables often differently occur in time and space. Their environmental heterogeneity usually makes mosaic patchy habitats favorable for survival of some plant species in the early vegetation process (Hartgerink and Bazzaz 1984). In the secondary vegetation and the managed vegetation, light and soil moisture are the most important factors controlling the early population structure (Hong and Nakagoshi 1998a).

Fig. 3 shows the results of germination and growth of two species by vegetation types. Vegetation types had different vegetation structure and environmental condition. Distinctly, these types are discerned from each other by light condition and vegetation cover (Table 2). In the case of pine population, the number of germinated current seedlings was highest at PDM type among four types. Saplings also survived much more than other types. However, saplings decreased by year, and its trend was similar to G-type. It demonstrates the intensive human activity on undergrowth of forest. In the case of G-type, all saplings of woody species were cut for graveyard management (Hong *et al.* 1993).

Oak seedlings did not so much germinate as pine at the same period. It was concerned with dispersal distance from mother tree of *Quercus* species having both geochory and synzoochory patterns. In addition, forest animals (e.g. *Sciurus vulgaris* and *Tamias sibiricus*) can disperse acorns by caching usually avoiding an open space without shelter and habitat geometry for their movement (Hong and Rim 1997). Germination of dispersed acorns was also inhibited by deep root-net of grass *Zoysia japonica* (Hong and Nakagoshi 1998b).

PDM-type was relatively more abundant than other types ($p < 0.05$). FE-type between G-type and other vegetation patch shows many old saplings ($p < 0.05$). Microheterogeneity of FE-type

Table 2. Mean (standard deviation) of vegetation and environmental variables of surveyed plots of vegetation type. RLI*p* is relative light intensity measured by hemispherical photography. PD: *Pinus densiflora - P. rigida* unmanaged forest, PDM: *Pinus densiflora* managed forest, FE: Forest edge, G: Graveyard.

Variable	Vegetation type			
	PD	PDM	FE	G
Vegetation				
Cover(%) of tall-tree layer	80.5(24.5)	88.5(5.5)	50.5(25.5)	0
sub-tree layer	56.7(12.5)	15.5(3.4)	13.2(5.4)	0
shrub layer	66.5(30.4)	7.2(5.5)	14.5(7.5)	0
herb layer	70.5(5.5)	27.7(15.4)	30.5(10.4)	76.6(15.6)
Cover of litter	58.9(15.3)	45.5(24.5)	30.4(20.5)	6.5(0.9)
Ratio(%) of woody plants	80.3(5.6)	74.5(4.3)	70.5(6.3	0.5
herbaceous plants	19.7(2.5)	25.5(3.5)	29.5(5.5	99.5
evergreen plants	5.5(3.0)	6.5(1.1)	6.1(1.0)	1.0(0.2)
Environment				
Light internsity RLI*p*(%)	35.8(13.2)	45.2(20.1)	56.3(15.2)	60.5(23.2)
Soil properties pH	4.6(0.8)	4.7(1.2)	5.0(1.3)	5.5(2.1)
C/N(%)	29.2(2.8)	35.3(11.9)	38.3(5.3)	30.5(12.5)

existing between PDM and graveyard caused by topography and abiotic conditions such as proper

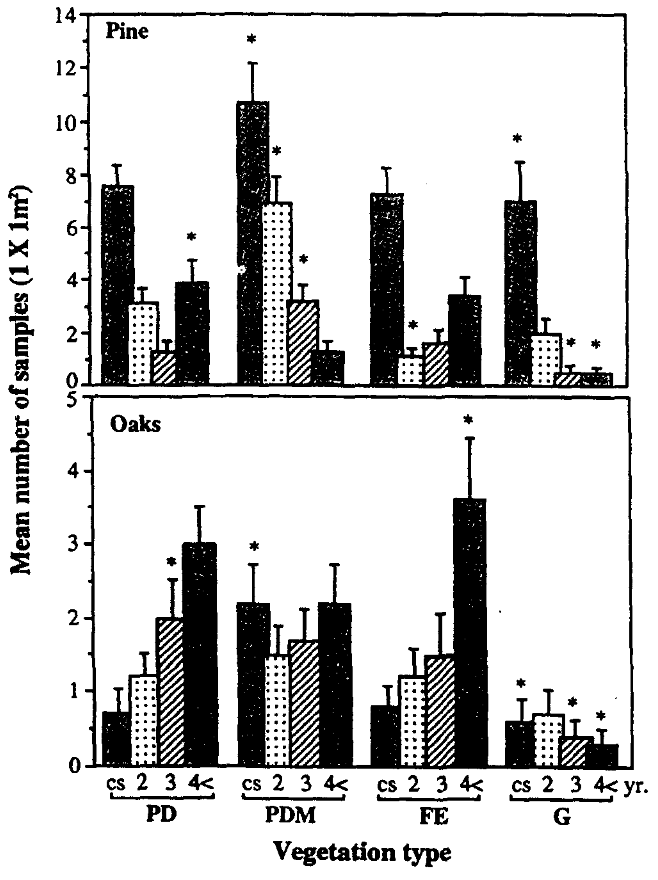

Fig. 3. Mean number of seedlings and saplings of pine and oaks in different vegetation types. PD: *Pinus densiflora-P. rigida* forest, PDM: *Pinus densiflora* managed forest, FE: Forest edge, G: Graveyard, cs: Current seedling. Significant difference (Fisher's PLSD test) at $p<0.05$ represented by asterisk. Bar shows a standard error.

light and nutrient soil sometimes can contribute to plentiful seed bank combined by both vegetation types. Germination of many herbaceous plants and woody species having several seed dispersal forms can be observed in this type (Hong pers. comm.). It means that FE-types have reasonable resource places available for plant materials such as seeds and young trees for vegetation restoration. Therefore, forest management considering these factors is necessary for maintaining vegetation landscape.

In this study, environmental condition of PDM-type is favorable for germination of both species. However, many mortal factors inhibiting the successful completion of germination are waiting (Hong and Rim 1997, Hong and Nakagoshi 1998a). Therefore, structure of initial demography (esp. seedling stage) may be changed according to mortality in a full year's research.

Effects of patch shape on germination

Germination of pine (esp. *P. densiflora*) approximately continued until late June, and then the germinated seedlings died by several biotic or abiotic mortal factors such as drought, rooting-out and predators (Hong and Rim 1997, Hong and Nakagoshi 1998a). The performance of germination is affected by mosaic vegetation type because the characteristics of vegetation (landscape) patches decide the difference of occurrence of those mortal factors (Verboom and van Apeldoorn 1990, Fitzgibbon 1997, Hong and Rim 1997, Tamura 1998).

Fig. 4 explains the effect of patch shape on germination of both species using several patch indices in graveyard. In the results, we could not compare the saplings because they were removed during management of graveyard. Therefore, this result was on the early stage of germination for the three months since April 1998. The number of pine seedlings increased with patch size and its perimeter (Pearson's correlation coefficient, r=0.359 to area, r=0.479 to perimeter, $p<0.05$): In contrast, those of oak seedlings were not significant ($p>0.1$). Larger graveyards provided higher light availability for the germination of pine seedlings. Light condition (duration of daylight), however, negatively act as mortal factor fostering dry soil by heat (Hong and Nakagoshi 1998a). Most seedlings of both species in the large sized graveyards without shade, therefore, will die more easily than those in small sized ones before monsoon.

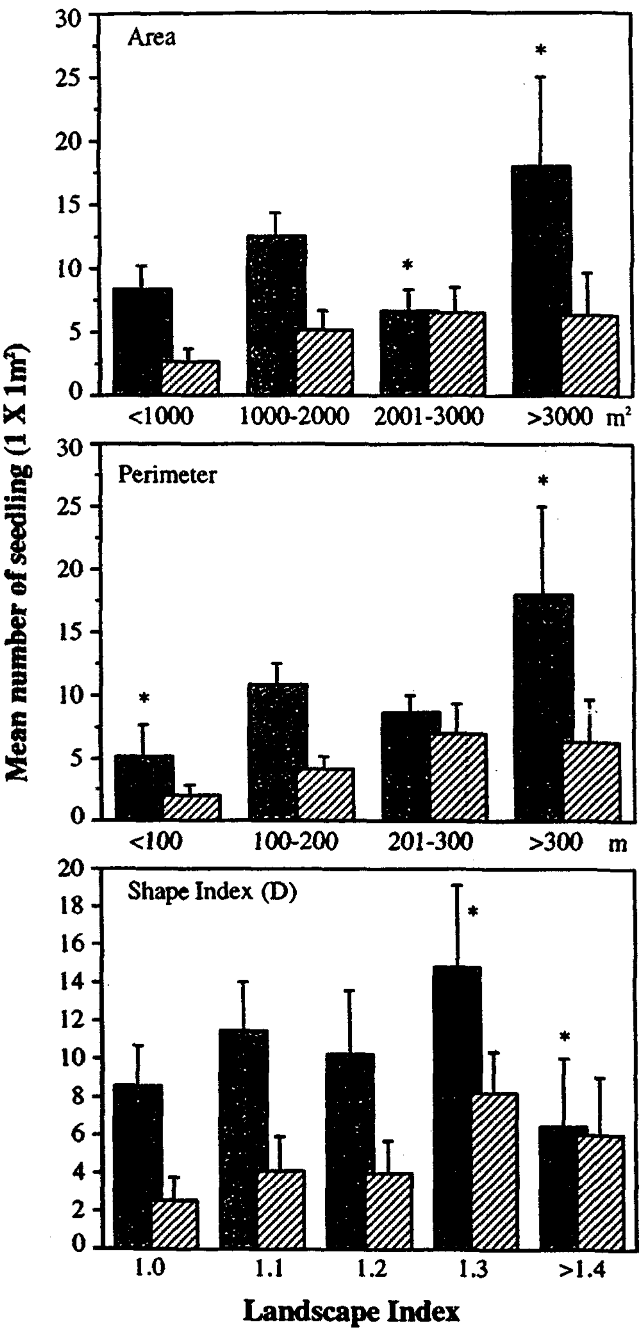

Fig. 4. Mean number of current seedlings of pine and oaks by shape indices of area, perimeter length and shape indices (D) of graveyard. Closed box: pine, Hatched box: oaks. Significant difference (Fisher's PLSD test) at $p<0.05$ represented by asterisk. Bar shows a standard error.

According to Forman (1995), the colonization and extinction of plant species are dependent on the size and shape of disturbed patch because a patch's geometry can supply the favorable habitats with high light availability and rich nutrients. However, detailed relationship between patch shape and germination of two woody species can not be explained yet in these results. More information about floristic composition of the total species and its dynamics of different sized graveyard is necessary to get a clue for the concept above-mentioned.

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