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The Pattern of Natural Regeneration by Canopy Gap Size in the Mixed Broadleaved-Korean Pine Forest of Xiaoxing`an Mountains, China

Guangze Jin[1], Yueying Tian[1], Fengxia Zhao[1] and Ji Hong Kim[2*]

[1]*School of Forestry, Northeast Forestry University, Harbin, 150040, China*
[2]*College of Forest and Environmental Sciences, Kangwon National University, Chuncheon 200-701, Korea*

Abstract : The forest canopy gap has been well known as a substantial process of forest cyclic regeneration and important role in stand structure, dynamics, and biodiversity of the forest ecosystem. Based on 3,600 5 m×5 m square grids in a 9ha permanent experimental plot, the study was conducted to evaluate the regeneration pattern of woody species by developmental stage {seedlings (<1 m of height), saplingI (>1 m of height, <2 cm of DBH), and saplingII (2 cm<DBH<5 cm)} for different size of forest canopy gaps (<200 m^2, 201-400 m^2, 400-600 m^2, 601-800 m^2, and >800 m^2) in the mixed broadleaved-Korean pine forest. The results indicated that the regenerating trees of *Populus ussuriensis* occurred only in the canopy gap area, considered to be a typical gap-dependent species. The regeneration of *Ulmus japonica*, *Ulmus laciniata*, and *Maackia amurensis* could be generally satisfied with the gap size of 201-600 m^2, *Betula costata* and *Prunus padus* with gap size of 401-800 m^2, *Picea koraiensis* with gap size of 201-800 m^2, *Fraxinus mandshurica* and *Syringa reticulata* var. *mandshurica* with smaller than 800 m^2, respectively. *Acer ukurunduense* and *Acer tegmentosum* were likely to have no problem with the gap size to make gap regeneration. *Acer mono* and *Tilia amurensis* looked more capable of regenerating in the closed canopy disregarding the upper crown condition. The regeneration of *Pinus koraiensis* and *Abies nephrolepis* had no trouble under the canopy condition in less than 800 m^2 of gap size. The density of regenerating shrubs was rather high, especially under the closed canopy, considered to be associated with great amount of regeneration production in such shade tolerant species as *Lonicera maackii*, *Corylus mandshurica*, *Euonymus pauciflorus*, and *Philadelphus schrenkii* under the closed canopy. Pearson correlation coefficient was computed to compare the similarity among non-gap area and five gap size classes by developmental stages for trees and shrubs. The similarity coefficients among closed canopy and the gap size classes were mostly significantly correlated to each other with a few exceptions.

Key words **:** *mixed broadleaved-Korean pine forest, forest gap, seedling, sapling, gap size, regeneration*

Introduction

Forest canopy gaps are formed by the fall or death of one or several canopy trees, considered to be a substantial process of forest cyclic regeneration (Lertzman, 1992). Light condition of gap site could be definitely improved by gap formation, influencing on the temperature and moisture condition (Ritter *et al.*, 2005) as well as on the soil physical and chemical properties in the gap (Clarke and Kerrigan, 2000). Forest canopy gaps promote the coexistence of species having different resource use strategies and dispersal and competitive abilities (Connell, 1978; Paine and Levin, 1981). On the whole gap formation plays a particularly important role in stand structure, dynamics, and biodiversity of the forest ecosystem (Kneeshaw and Bergeron, 1998; Hubbell *et al.*, 1999; Schnitzer and Carson, 2001).

The mixed broadleaved-Korean pine forest was one of the major forest types in northeast region of China, once being extensively distributed as a climax forest type. The distribution of this forest type is presently restricted in the area of Changbai mountains of Jilin Province; Wanda mountains, Laoye mountains, Zhangguangcai mountains, and Xiaoxing`an Mountains of Heilongjiang Province, mainly by the misuse of forest land and over-harvesting

*Corresponding author
E-mail: kimjh@kangwon.ac.kr
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of timber (Wang, 1995). Some of Chinese researchers have reported the effect of forest canopy gap on the stand regeneration (Zang *et al.*, 1998; Wu, 1998; Guo *et al.*, 1998; Zang and Xu, 1999; Zang *et al.*, 1999a; Yu *et al.*, 2001), and regeneration response of main tree species to gap size and gap development phase in the mixed broadleaved-Korean pine forest (Zang *et al.*, 1999b). However, no studies have been conducted on the regeneration pattern of major tree species by developmental stage in various size of forest canopy gaps. Accordingly, this study was carried out to experiment on the regeneration pattern of major tree species by developmental stage for different size of forest canopy gaps in the mixed broadleaved-Korean pine forest.

Material and Methods

The study was conducted in the mixed broadleaved-Korean pine forest, located in Liangshui National Reserve of Xiaoxing`an Mountains. The Reserve is characterized by rolling mountainous terrain with 707.4 m of highest peak above sea level and 300 m of lowest peak a.s.l., and average slope gradient is 10-15°C. Mean annual temperature is -0.3°C with mean annual highest temperature of 7.5°C and lowest temperature of -6.6°C. Mean annual precipitation is 676 mm with 78% of relative humidity and 805 mm of evaporation rate (Jin *et al.*, 2006).

The Laingshui National Reserve extended 12,133ha of total land area with about 1.7 million m^3 of growing stock and 98% of canopy coverage. The Reserve has one of the most concentrated and well-conserved patch shape broadleaved-Korean pine replaced by secondary forests after major disturbances from over-harvesting around the region. Having been rich in vegetation and community type, the Forest is composed of *Pinus koraiensis*, *Picea koraiensis*, *Abies nephrolepis*, *Tilia amurensis*, *Tilia mandshurica*, *Acer mono*, *Fraxinus mandshurica*, *Ulmus laciniata*, *Betula costata*, *B. platyphylla*, *Quercus mongolica*, *Larix gmelini*, *Juglans mandshurica*, *Acer ukurunduense*, and *A. tegmentosum* (Jin *et al.*, 2006).

A permanent experimental plot of 300 m×300 m was established in the typical broadleaved-Korean pine forest in the year of 2005, divided into 900 10 m×10 m sub-plots and planted stakes on the corner of each sub-plots to mark the position. For every woody plant greater than 2cm of diameter, we attached the aluminum number tag, placed coordinates on the grid map, and measured DBH, height, crown width, and bole height.

Nine hundred 10 m×10 m sub-plots were divided again into 3,600 5 m×5 m square grid. In every 5 m×5 m grid, if the crown projection area of trees (total height of >10 m) was less than 30%, we regarded the grid as the forest canopy gap (Babweteera *et al.*, 2000). The grid of 5 m×5 m was the basic unit of area measure of the gap. Hence, one specific gap could be composed of several adjacent grids.

The regeneration pattern of tree and shrub species by the size of canopy gap was examined on the basis of five gap size classes and one control, i.e., non-gap area. Five gap size classes were <200 m^2, 201-400 m^2, 400-600 m^2, 601-800 m^2, and >800 m^2. Twenty sample plots were randomly established in each size class and non-gap area. The regeneration process was divided into seedlings stage (height of <1 m), sapling I stage (height of >1 m, DBH of <2 cm), and sapling II stage (2 cm < DBH < 5 cm). The size of sample plot was 2 m×2 m for seedlings and saplingI, and 5 m×5 m for sapling II. For every regenerating trees and shrubs, we identified the species, measured the height, placed the coordinate, and attached the aluminum tag with consecutive number.

Pearson correlation coefficient was computed to compare the similarity among non-gap area and five gap size classes by developmental stage (seedling, sapling I, sapling II) for trees and shrubs (Krebs, 1999).

Results and Discussion

1. Size distribution of the canopy gaps

We recognized 201 forest canopy gaps, summed up 2.49ha, occupying 27.7% of the 9ha permanent plot in the mixed broadleaved-Korean pine forest of Liangshui National Reserve of Xiaoxing`an Mountains (Figure 1). The proportion of canopy gap was much greater than that of Jiaohe region in Jilin Province of 12.5% of total forest land area (Zang and Xu, 1999), and still somewhat

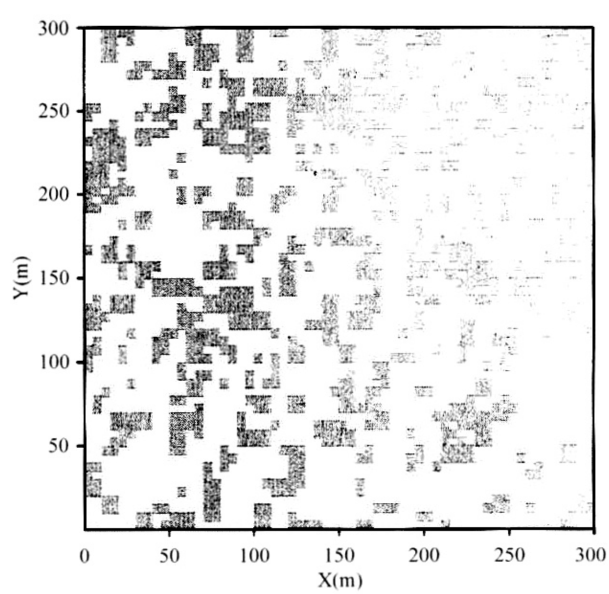

Figure 1. Map of the 9ha permanent plot for gaps in the mixed broadleaved-Korean pine forest. White and grey areas represent closed canopy and canopy gaps, respectively.

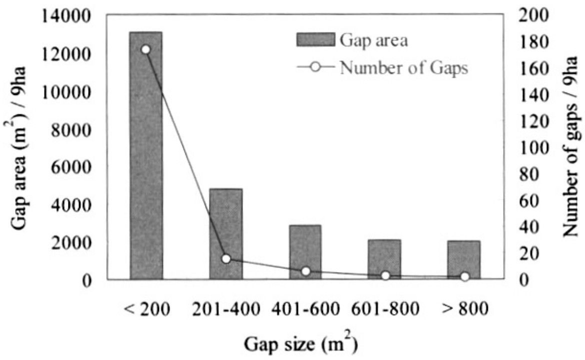

Figure 2. Size distribution of gaps in the 9ha plot of the mixed broadleaved-Korean pine forest.

higher than that of Changbai Mountain Reserve of 25.6% (Guo *et al*, 1998). The area of canopy gap ranged from 25 m^2 to 1,025 m^2, averaging 124 m^2. The number of canopy gaps less than 200 m^2 was 174, occupying 86.6% of the total canopy gap number and 52.6% of the total gap area (Figure 1). As the size class of canopy gap was increased, the number and area were gradually decreased, presenting a typical reverse J-shape distribution (Figure 2).

2. Regeneration pattern by the size of canopy gap

As indicated in Table 1, the number of regenerating trees showed great variation by species, developmental stages, and the gap size classes. In the canopy gaps, the gap size class of 410-600 m^2 contained the largest amount of regenerating individuals per unit area, counted as 10,500, 5,250, and 800 for seedlings, saplingIs, and saplingIIs, respectively (Table 1). As the gap size became smaller or bigger, the number of regenerating individuals were decreased, showing the single-hump distribution. Total amount of regenerating trees in the non-gap area was similar to the numbers in the gap size class of 201-400 m^2 for all three developmental stages.

The result of this study hardly consented to the report of Zang *et al.* (1999b), which noted that the number of major tree species showed the single-hump distribution as the size of gaps were increased, and the density of trees in canopy gaps was higher than that in closed canopy. In the size class of >800 m^2, the occurrence of seedling and saplingI was poor, mainly because of high ground coverage of herbaceous plants. Generally, as developmental stage progressed from seedling via saplingI to saplingII, the number of individuals of regenerating trees tended to be decreased.

For the developmental stage of seedling, *Rhamnus davurica*, *Betula costata*, *Maackia amurensis*, and *Picea koraiensis* were presented only in the canopy gap area. The seedlings of *Ulmus laciniata* and *Abies nephrolepis* showed the highest density in the gap size class of <200 m^2, *Syringa reticulata* var. *mandshurica* in the class of 401-600 m^2, *Fraxinus mandshurica* in the classes of 201-400 m^2 and 401-600 m^2, and *Acer tegmentosum*, *Acer mono*, and *Tilia amurensis* in the closed canopy.

For the stage of saplingI, *Betula costata*, *Maackia amurensis*, and *Picea koraiensis* still appeared only in the canopy gap area, besides, we could find the saplingI of *Ulmus laciniata*, *Syringa reticulata* var. *mandshurica*, *Prunus padus*, and *Abies nephrolepis* only in the gap, showing the highest density in the gap size classes of 401-600 m^2 or 601-800 m^2. SaplingIs of *Fraxinus mandshurica* were most in the size class of 401-600 m^2, and *Acer ukurunduense* and *A. tegmentosum* were most in the class of 601-800 m^2.

Individual saplingIIs of *Ulmus japonica*, *Betula costata*, *Prunus padus*, and *Populus ussuriensis* were presenting a common tendency to increase as the gap size class got larger, showing the greatest number in the class of 401-600 m^2, and decreased again. On the other hand, *Acer tegmentosum* made an appearance most in the class of >800 m^2. Even though each species presented no particular trend in the distribution of saplingIIs by the gap size class, three maple species had relatively higher number of regenerating individuals in every gap size class.

The regenerating trees of *Populus ussuriensis* occurred only in the canopy gap area, considered to be a typical gap-dependent species. The findings from Table 1 indicated that the regeneration of such species as *Ulmus japonica*, *U. laciniata*, and *Maackia amurensis* could be generally satisfied with the gap size of 201-600 m^2, *Betula costata* and *Prunus padus* with gap size of 401-800 m^2, *Picea koraiensis* with gap size of 201-800 m^2, *Fraxinus mandshurica* and *Syringa reticulata* var. *mandshurica* with smaller than 800 m^2, respectively. *Acer ukurunduense* and *A. tegmentosum* were likely to have no problem with the gap size to make gap regeneration. *Acer mono* and *Tilia amurensis* looked more capable of regenerating in closed canopy disregarding the upper crown condition. The regeneration of *Pinus koraiensis* and *Abies nephrolepis* seemed to have no trouble under the canopy condition in less than 800 m^2 of gap size.

Guo *et al.* (1998) compared the densities of composed tree species for less than 10 cm of DBH between in the forest gap and in closed canopy. The research results noted that the canopy gap formation was seldom associated with the regeneration of *Tilia* species, but caused the reduction of the amount of *Acer mono* saplings which maintained high density in closed canopy, showed similar results to this study.

In addition, Zang and Xu (1999) evaluated the dependency of composed tree species on canopy gap formation between in the forest gap and in closed canopy

Table 1. The number of individuals per hectare of three developmental stages for major tree species among gap size classes in the mixed broadleaved-Korean pine forest.

Developmental stage	Species	Non-Gap	Gap area (m^2)				
			< 200	201-400	401-600	601-800	> 800
Seedling	*Ulmus japonica*	250	125	625	125	125	0
	Rhamnus davurica	0	0	250	0	0	0
	Betulla costata	0	0	0	125	500	0
	Fraxinus mandshurica	875	1,250	1,750	1,750	625	375
	Ulmus laciniata	250	1,375	125	500	500	250
	Syringa reticulata var. *mandshurica*	1,500	1,250	625	5,875	1,750	0
	Prunus padus	250	0	125	250	0	0
	Maackia amurensis	0	0	0	125	0	125
	Acer ukurunduense	125	500	125	0	500	0
	Acer tegmentosum	1,750	500	1,500	125	0	125
	Acer mono	1,875	125	750	750	500	375
	Tilia amurensis	750	125	250	250	250	500
	Picea koraiensis	0	0	500	250	0	0
	Pinus koraiensis	125	0	125	125	0	0
	Abies nephrolepis	250	875	500	375	375	0
	Total	8,000	6,125	7,250	10,625	5,125	1,750
SaplingI	*Ulmus japonica*	750	125	250	500	125	0
	Betulla costata	0	125	0	125	375	0
	Fraxinus mandshurica	125	125	0	375	0	125
	Ulmus laciniata	0	0	375	1,750	250	0
	Syringa reticulata var. *mandshurica*	0	250	500	375	0	0
	Prunus padus	0	0	0	250	250	0
	Maackia amurensis	0	0	0	875	0	0
	Acer ukurunduense	125	125	125	0	625	125
	Acer tegmentosum	125	125	125	0	1,000	0
	Tilia mandshurica	125	0	0	0	0	0
	Acer mono	625	250	375	625	0	0
	Tilia amurensis	375	0	0	375	375	250
	Picea koraiensis	0	0	125	0	125	0
	Abies nephrolepis	0	0	125	0	0	0
	Total	2,250	1,125	2,000	5,250	3,125	500
SaplingII	*Ulmus japonica*	20	40	40	280	0	0
	Betulla costata	20	220	100	460	80	40
	Fraxinus mandshurica	20	140	0	80	120	0
	Ulmus laciniata	140	60	200	240	60	160
	Syringa reticulata var. *mandshurica*	200	0	120	80	140	0
	Prunus padus	40	20	40	820	140	0
	Maackia amurensis	20	0	0	0	20	0
	Acer ukurunduense	300	460	700	360	440	680
	Acer tegmentosum	80	40	100	120	320	200
	Populus ussuriensis	0	120	100	340	0	0
	Acer mono	600	140	60	100	240	220
	Tilia amurensis	200	40	140	140	60	60
	Picea koraiensis	20	0	0	0	40	20
	Pinus koraiensis	80	0	0	20	140	0
	Abies nephrolepis	0	0	40	0	120	0
	Others (11species)	40	40	60	200	120	160
	Total	1,780	1,320	1,700	3,240	2,040	1,540

Table 2. The number of individuals per hectare of three developmental stages for shrubs among gap size classes in the mixed broadleaved-Korean pine forest.

Developmental stage	Species	Non-Gap	Gap area (m²)				
			<200	201-400	401-600	601-800	>800
Seedling	*Ribes burejense*	0	375	0	0	125	250
	Viburnum sargenti	0	125	0	0	0	375
	Aralia mandshurica	0	250	250	625	375	875
	Sorbaria sorbifolia	0	125	1,375	1,500	750	1,125
	Loniceara caeurulea	125	0	0	0	0	0
	Rosa koreana	0	0	250	0	125	125
	Viburnum burejaeticum	0	0	1,125	0	0	0
	Corylus mandshurica	4,375	125	2,250	875	875	750
	Berberis amurensis	875	0	0	250	375	0
	Euonymus pauciflorus	4,125	2,000	3,625	875	3,250	1,750
	Spiraea spp.	500	125	125	0	375	0
	Deutzia glabata	5,750	6,125	5,750	5,500	8,375	2,875
	Lonicera maackii	10,500	5,125	5,500	1,500	3,250	5,000
	Ribes manshuricum	1,375	125	625	0	0	1,375
	Acanthopanax senticosus	1,250	1,250	250	1,000	375	625
	Philadelphus schrenkii	3,750	2,875	2,500	1,500	1,250	2,000
	Total	32,625	18,625	23,625	13,625	19,500	17,125
SaplingI	*Ribes burejense*	0	0	0	0	0	125
	Viburnum sargenti	0	0	0	0	250	0
	Aralia mandshurica	0	0	0	125	0	125
	Sorbaria sorbifolia	0	0	0	375	0	875
	Loniceara caeurulea	0	0	0	0	250	0
	Viburnum burejaeticum	0	0	500	0	0	0
	Corylus mandshurica	4,125	125	4,000	1,125	1,875	1,250
	Berberis amurensis	250	0	0	250	0	0
	Euonymus pauciflorus	625	875	750	625	875	500
	Spiraea spp.	0	0	0	125	125	0
	Deutzia glabata	750	2,500	2,500	1,500	2,625	1,875
	Lonicera maackii	500	625	500	375	250	1,375
	Ribes manshuricum	375	375	375	0	250	250
	Acanthopanax senticosus	750	1,750	250	1,500	2,000	2,125
	Philadelphus schrenkii	1,750	625	375	1,375	1,500	1,125
	Total	9,125	6,875	9,250	7,375	10,000	9,625
SaplingII	*Viburnum sargenti*	0	0	0	0	60	0
	Aralia mandshurica	20	120	20	160	60	20
	Sambucus coreana	20	0	0	80	0	0
	Corylus mandshurica	1,400	1,460	1,680	2,560	1,060	1,480
	Euonymus pauciflorus	200	80	40	20	160	80
	*Actinidia kolomikta**	0	60	0	20	20	0
	Lonicera chrysantha	0	0	140	0	20	20
	Deutzia glabata	20	0	0	0	40	0
	Acanthopanax senticosus	0	80	0	0	40	220
	Philadelphus schrenkii	40	80	80	0	40	20
	Total	1,700	1,880	1,960	2,840	1,500	1,840

based on the rank of importance values. The results indicated that canopy gap formation was advantageous to the regeneration of *Betula costata*, *Ulmus laciniata*, *Acer ukurunduense*, and *Acer tegmentosum*, on the contrary, it acted unfavorable condition for the regeneration of *Pinus koraiensis*, *Fraxinus mandshurica*, *Tilia amurensis*, and *Ulmus japonica*, and no influence on the regeneration of *Acer mono* and *Abies nephrolepis*. Their report partly

Table 3. Pearson correlation coefficient for three developmental stages of trees and shrubs among canopy gap size classes in the mixed broadleaved-Korean pine forest.

	Non-Gap	Gap area (m^2)				
		<200	201-400	401-600	601-800	>800
Seedling (trees)	Seedling (trees)					
Non-Gap	-					
< 200	0.59*	-				
201-400	0.81**	0.67**	-			
401-600	0.70**	0.81**	0.80**	-		
601-800	0.66**	0.80**	0.52*	0.78**	-	
> 800	0.66**	0.49	0.60*	0.65**	0.39	-
SaplingI(trees)	SaplingI(trees)					
Non-Gap	-					
< 200	0.61*	-				
201-400	0.52	0.77**	-			
401-600	0.40	0.37	0.67**	-		
601-800	0.30	0.44	0.31	0.25		
> 800	0.38	0.23	0.06	0.21	0.42	-
SaplingII(trees)	SaplingII(trees)					
Non-Gap	-					
< 200	0.58**	-				
201-400	0.58**	0.88**	-			
401-600	0.35	0.58**	0.52**	-		
601-800	0.73**	0.76**	0.78**	0.53**	-	
> 800	0.67**	0.85**	0.92**	0.40*	0.83**	-
Seedling (shrubs)	Seedling (shrubs)					
Non-Gap	-					
< 200	0.89**	-				
201-400	0.94**	0.93**	-			
401-600	0.70**	0.88**	0.85**	-		
601-800	0.77**	0.92**	0.90**	0.95**	-	
> 800	0.95**	0.91**	0.93**	0.74**	0.77**	-
SaplingI(shrubs)	SaplingI(shrubs)					
Non-Gap	-					
< 200	0.37	-				
201-400	0.88**	0.53*	-			
401-600	0.73**	0.85**	0.69**	-		
601-800	0.74**	0.88**	0.78**	0.96**	-	
> 800	0.64**	0.86**	0.65**	0.94**	0.90**	-
SaplingII(shrubs)	SaplingII(shrubs)					
Non-Gap	-					
< 200	0.99**	-				
201-400	0.99**	0.99**	-			
401-600	0.99**	0.99**	0.99**	-		
601-800	0.99**	0.99**	0.99**	0.99**	-	
> 800	0.98**	0.99**	0.99**	0.99**	0.99**	-

*, ** : Significant at P<0.05, P<0.01.

consented to the results of this study, because of different experimental methods and subject trees of investigation. The dissimilarity could be found on the research of Yu *et al.* (2001) due to the difference of evaluation criteria.

The occurring status of regeneration shrubs for each developmental stage was presented in Table 2 by the gap size classes. The developmental stages of seedling and saplingI shrubs were coming in much more numbers than those of trees, but saplingII shrubs were growing similar amount to that of trees. As developmental stage progressed from seedling via saplingI to saplingII, the number of individuals of regenerating shrubs tended to be decreased, having noticed no common regularity in regeneration occurrence by gap size classes.

The greatest amount of seedlings were surveyed for such shrub species as *Deutzia glabata, Lonicera maackii, Euonymus pauciflorus*, *Philadelphus schrenkii, Corylus mandshurica*, and *Acanthopanax senticosus* in every gap size class. For the developmental stage of saplingI, *Corylus mandshurica, Deutzia glabata, Acanthopanax senticosus, Philadelphus schrenkii, Euonymus pauciflorus*, and *Lonicera maackii* were recorded as dominant shrub species. *Corylus mandshurica* had the largest number in saplingII stage.

Being similar to tree regeneration pattern, there were a considerable number of shrub species occurring only in the canopy gap area. Those shrub species were *Ribes burejense, Viburnum sargenti, Aralia mandshurica, Sorbaria sorbifolia, Rosa koreana*, and *Viburnum burejaeticum* in seedling stage; *Ribes burejense, Viburnum sargenti, Aralia mandshurica, Sorbaria sorbifolia, Loniceara caeurulea, Viburnum burejaeticum*, and *Spiraea* spp. in saplingI stage, and *Lonicera chrysantha* and *Philadelphus schrenkii* in saplingII stage, respectively. The regenerating shrubs of *Corylus mandshurica, Euonymus pauciflorus, Lonicera maackii*, and *Philadelphus schrenkii* had higher density in closed canopies than in canopy gaps.

Comparatively better performance in canopy gap area was recognized for the species of *Ribes burejense, Viburnum sargenti, Aralia mandshurica, Sorbaria sorbifolia, Loniceara caeurulea*, and *Viburnum burejaeticum*. However, regeneration of such species as *Corylus mandshurica, Berberis amurensis, Euonymus pauciflorus, Deutzia glabata, Lonicera maackii, Ribes manshuricum, Acanthopanax senticosus*, and *Philadelphus schrenkii* were growing fairly well without regard to upper canopy conditions.

The density of regenerating shrubs of this study was much higher than that of the study in Changbai Mountain Natural Reserve done by Zang *et al.* (1998), especially under the closed canopy for seedling stage. The fact was considered to be associated with great amount of regeneration production in such shade tolerant species as *Lonicera maackii, Corylus mandshurica, Euonymus pauciflorus*, and *Philadelphus schrenkii* under the closed canopy.

3. Similarity of regeneration by the size of canopy gap

The results of Pearson correlation coefficient was summarized in Table 3, which was computed to compare the similarity among non-gap area and five gap size classes by developmental stage (seedling, saplingI, and saplingII) for trees and shrubs. In tree developmental stages of seedling and saplingII, the similarity coefficients among closed canopy and the gap size classes were mostly significantly correlated to each other at $P<0.05$ or $P<0.01$ level, with the exception of between the size class of <200 m^2 versus >800 m^2, and 601-800 m^2 versus >800 m^2 of seedling stage, and between non-gap versus 401-600 m^2 of saplingII stage. On the other hand, in saplingI stage, not many pairs of size classes were significantly correlated to each other (Table 3), presumed the state from Table 1, of which survey data looked sparse and irregular.

In all shrub developmental stages of seedling, saplingI, and saplingII, the similarity coefficients among non-gap and the gap size classes were commonly significantly correlated to each other at $P<0.05$ or $P<0.01$ level, with the exception of between the non-gap area versus the size class of <200 m^2 of saplingI stage (Table 3).

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