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Population Dynamics of *Pinus densiflora* for. *erecta* at Sokwang-Ri, Uljin-Gun in Southeastern Korea

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ABSTRACT : Population dynamics of the oldest relic stand of *Pinus densiflora* for. *erecta* which remains as a status of patch in Sokwang-Ri area, Uljin-Gun, was studied to provide the basic data for conservation of the oldest pine stand in Korea. The upper slope site and ridge site including total 12 plots mainly represented *Pinus densiflora* for. *erecta* and *Quercus mongolica*. These two tree species showed reverse J-shaped distribution. From this information, it was concluded that intensive interspecific competition between two species could be occurring. Age distribution of *P. densiflora* for. *erecta* on the sites above middle slope area was indicated bi-modal type or tri-modal type which was known as an age structure of climax forest. Therefore, it was estimated that *Pinus densiflora* for. *erecta* population could be continuously maintained in the each patch above middle slope area. In the valley sites, hardwood species such as *Q. mongolica, Q. variabilis, Styrax obassia* and *Acer pseudosieboldianum* occupied most part of the under crown-cover area and their seedlings and saplings were developing into the closed upper layer crown because the height of upper layer crown reached about 35 meters and such a high crown height was more suitable for light utilization by plants of under layer. The growth patterns were mainly fluctuated for the entire life time of the oldest tree caused by frequent disturbance. And the initial growth curves of the mature trees and suppressed juvenile trees showed different tendencies along the sites.

Key words : Disturbance, Dynamics, *Pinus densiflora* for.*erecta*, Population, Sokwang-Ri.

INTRODUCTION

The balance of nature has been a background concept in community ecology (Egerton 1973). In contrast to the concept, the variability of biological populations has been appreciated in nature, such as in outbreak and extinction of species. The two concepts have been transformed into density dependent and density independent regulation in population dynamics and then into equilibrium and non-equilibrium community theories. The competition-equilibrium community theory has been advanced in the empirical and theoretical studies of community and has explained the community organization by the niche theory. The non-equilibrium community theory has argued the importance of non-equilibrium conditions of populations in nature and the reconsideration of community organization from the individualistic or auto-ecological studies of populations constituting communities (MacArthur 1958,1968, Strong 1983). In the recent, community ecology has advanced in the diversity studies, competitive-equilibrium and non-equilibrium community theories and now is entering a new stage over these past community studies(Takeda 1986).

Population dynamics was defined as a research of the change of the population structure with time, including movement of the population before or after the disturbance(Oliver and Larson 1990).

In Korea, a lot of research on disturbance or dynamics of forest vegetation were carried out in order to manifest the regeneration process, spatial structure, disturbance regime and so on (Cho 1992, Lee and Cho 1993, Lee 1995, Kim and Song 1995, Bae and Hong 1996, Song and Jang 1997). Yun and Hong (2000) reported that the oldest pine stand remained in a patch of relic stand at Sokwang-Ri, Uljin-Gun, Korea. But there was no research about population dynamics of the pine forest in that area. Therefore, the objectives of this study were to describe the structure and the mechanism of the Pinus densiflora for. erecta which has been remained up to now and to provide the basic data for conservation of the oldest relic stand at Sokwang-Ri, Uljin-Gun, Korea.

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MATERIALS AND METHODS

Description of the study area

This study was carried out in Sokwang-Ri where is located in Uljin-Gun, Kyungsangpook Province, Korea (36° 59′ 00″ ~37° 03′ 00″ N, 129° 9′ 30″ ~129° 14′ 30″ E). The forest vegetation was characterized by *P. densiflora* for. *erecta* and *Q. mongolica.* It is secondary forest, which was dominated by disturbance and is in various growth stages. In this area, *P. densiflora* for. *erecta* forest distributed at various patches. Understory vegetation consisted of *Q. mongolica, Q. serrata, Populus davidiana, Fraxinus* spp., *Vaccinium koreanum, Spodiopogon cotulifer, Acanthopanax senticosus* and *Rhododendron micranthum* which had high coverage. In valley area, lots of individuals of *P. densiflora* for. *erecta* were dead as a standing dead type.

METHODS

Data was obtained from October 1996 to December 1998. The size of sample plots, with minimal area of 10m × 10m, was set with a total of 38 plots, which was divided into 32 plots (measured the number of individuals of major tree species in every DBH class) and 6 plots (measured height, diameter at brest height, crown height, the length of crown from 4 directions). And wood cores were collected with 153 individuals of *P. densiflora* for. *erecta* for the analysis of age distribution and with 28 individuals of major tree species distributed around gaps. Then, 35 individuals of pine trees below 8 cm of DBH which were difficult to use increment borer, were cut down and moved to laboratory, and their annual rings were measured by 0.01 mm. The ages of the trees were directly estimated from the number of annual rings. Radial growth rate from the obtained core was recalculated by modifying from pith to average radius.

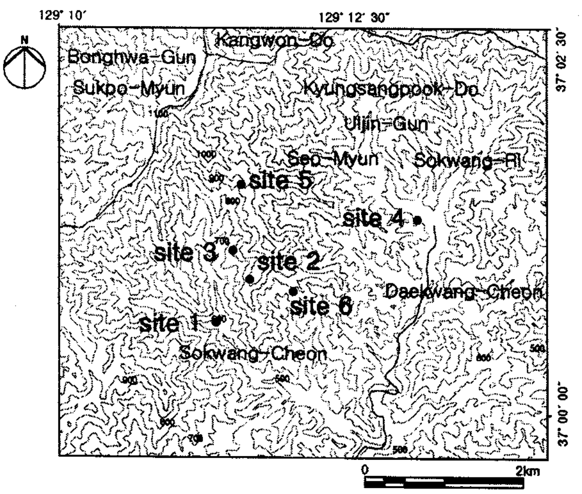


Fig. 1. A map showing the study area.

Table 1. Environmental characteristics of 6 plots

Plot	Topography	Altitude (m)	Aspect	Slope (°)	Bare rock (%)
1	Valley	590	S10E	15	20
2	Middle slope	790	N80W	40	10
3	Ridge	750	S70W	20	-
4	Valley	520	S70E	10	10
5	Upper slope	880	S60W	25	30
6	Middle slope	700	S60W	30	-

RESULTS AND DISCUSSION

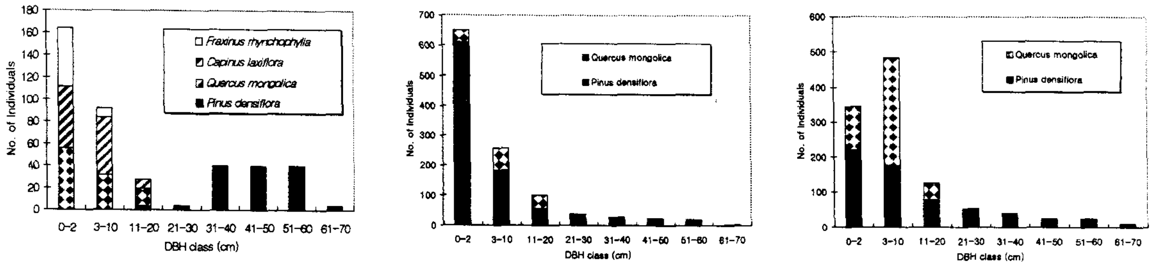
Population structure

Table 2 showed the number of individuals of major tree species in every DBH class distribution from 32 observations (10m × 10m) in Sokwang-Ri area. DBH class distributions generally furnish important information for judging whether population is sustainable or not (Lee 1993). Reverse J-shaped distribution includes 2 meanings. That is, if it is even-aged forest, it means competition (Ford 1975, Mohler *et al* 1978), and if it is uneven-aged forest, it means that the population could be maintained with property of climax forest or invasion population (Barbour *et al.* 1987). Reverse J-shaped distribution and regular distribution occasionally coexist in the nature, where if the number of individuals of the former is fewer than that of the latter, the latter is replaced by the former (Barbour *et al.* 1980). The investigated area overall consisted of tree species such as *P. densiflora* for. *erecta, Q. mongolica, F. rhynchophylla, Carpinus laxiflora* and etc., which was considered potentially to compete with each others, including interspecific competition and intraspecific competition. Especially the number of *P. densiflora* for. *erecta* individuals below 2 centimeter of DBH showed four times greater than that of *Quercus mongolica.* And the total number of individuals of the former was 934 which was compared by 422 individuals of the latter.

Fig. 2 showed the DBH class distribution of major tree species in the investigated areas (per 0.2ha), which was divided into three sites such as valley site, middle slope site and upper slope site according to topography. At the first, valley site including 5 plots represented tree species such as *P. densiflora* for. *erecta, Q. mongolica, F. mandshurica, F. rhynchophylla, C. laxiflora, Kalopanax pictus, Sorbus alnifolia, Juglans mandshurica, Prunus leveilleana, Acer mono, Q. variabilis* and etc. Among them, *P. densiflora* for. *erecta, Q. mongolica, C. laxiflora, F. rhynchophylla* and *Kalopanax pictus* were in the middle of competition to each other. *P. densiflora* for. *erecta* showed regular distribution above

Table 2. Number of individuals of major tree species in every DBH class distribution from 32 observations

Species	DBH class (cm)									Total
	0-2	3-6	7-10	11-20	21-30	31-40	41-50	51-60	61-70	
Pinus densiflora for. *erecta*	444	150	48	80	58	53	46	44	11	934
Quercus mongolica	114	166	73	65	2	1	1	-	-	422
Quercus serrata	14	-	2	4	8	1	-	-	-	29
Quercus variabilis	-	1	1	4	1	-	-	-	-	7
Fraxinus rhynchophylla	46	2	1	2	-	-	-	-	-	51
Fraxinus mandshurica	-	-	1	1	-	-	-	-	-	2
Carpinus laxiflora	26	8	13	2	1	-	-	-	-	50
Sorbus alnifolia	29	-	-		-	-	-	-	-	29
Tilia amurensis	7	1	2	1	-	-	-	-	-	11
Acer mono	1	3	-	4	-	-	-	-	-	8



<Valley site> <Middle slope site> <Upper slope and ridge site>

Fig. 2. DBH class distribution of major tree species in the investigated areas(per 0.2ha).

11 centimeter of DBH class, whereas *Q. mongolica, C. laxiflora* and *F. rhynchophylla* showed reverse J-shaped distribution below 20 centimeter of DBH class, and the individuals of these species were also very abundant. Therefore, it was considered that the population of *P. densiflora* for. *erecta* could be replaced by above mentioned species in the valley site.

P. densiflora for. *erecta* in the middle slope site including 10 plots showed reverse J-shaped distribution, although the site has a few individuals of *Q. mongolica*. Therefore, it was predicted that the population could be continuously remained with a climax property in the middle slope site.

The upper site and ridge site including 12 plots mainly represented *Pinus densiflora* for. *erecta* and *Q. mongolica*. These two tree species showed reverse J-shaped distribution. Therefore, it was estimated that interspecific competition between two species could be intensively occurred.

These results for the population structure could be useful materials to manifest how the relic species could be emerged about 200 years ago and have survived other species up to now, and to detect the maintain mechanism.

Age distribution

As was shown in Fig. 3, age distribution of *P. densiflora* for. *erecta* in site 1 and site 4 located in the each patch of valley area indicated the range from 50 to 75. It was a little different results compared with other reports that pine trees generally make the even-aged forest under the age of 20 years (Peet and Christensen 1980). Meanwhile, age structure of climax forest generally shows bi-modal type including mature trees and regeneration trees. But age distributions in these sites were not bi-modal types. Therefore, it was estimated that *P. densiflora* for. *erecta* population could not be continuously maintained in valley areas.

As was shown in Fig. 3, age distribution of *P. densiflora* for. erecta in sites 2, 3, 5 and 6 located in the each patch above middle slope area indicated bi-modal type or tri-modal type which were known as an age structure of climax forest. Therefore, it was estimated that *P. densiflora* for. *erecta* population could be continuously maintained in the each patch above middle slope area.

In conclusion, regeneration type of *P. densiflora* for. *erecta* forest in Sokwang region was divided into two kinds along the topography.

Spatial structure

Fig. 4 (a), (b) and (e) showed spatial distribution of individual trees which was divided into crown projection (horizontal structure) and stand profile (vertical structure). The all sites investigat-

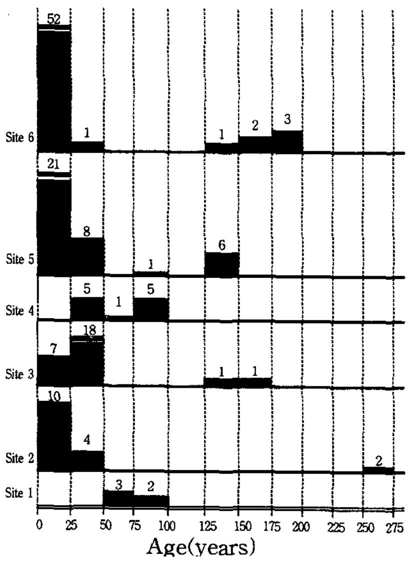


Fig. 3. Age distribution of *Pinus densiflora* for. *erecta* appeared in the study areas.

ed showed the overlapping of the crown covers along layers.

Among them, site 1 and site 4 typically demonstrated spatial pattern of valley area. At site 1, just 5 individuals (1, 2, 3, 9 and 10) occupied most part of the upper crown-cover area. In the understory, hardwood species of *Q. mongolica, Q. variabilis, Styrax obassia* and *Acer pseudosieboldianum* were growing. Dead trees such as the number 8 tree (standing dead type) and 12 tree (stem broken type) made many gaps, which *Q. mongolica* and *Q. variabilis* were invaded into. But seedlings and saplings of several species were developing into the closed upper layer crown instead of the gaps or openings. The reason was considered that the height of upper layer crown reached about 35 meters, and such a high crown height was more suitable for light utilization by plants of underlayer than low crown height.

At site 2, two individuals of *P. densiflora* for. *erecta* occupied about 50 percent of the upper crown-cover area, seven individuals of *Q. mongolica* were growing in middle layer, and individuals of *P. densiflora* for. *erecta* were also represented in low layer. Seedlings and saplings of *P. densiflora* for. *erecta* were developing into the gaps and the closed crown area of upper layer. Three individuals of dead pine trees did not belong to the any dead types studied by Nakashizuka (1984), but it was considered that the dead pines were due to forest fire in this area. These results were almost the same compared with the consideration of Cho (1994).

At site 3 investigated in the ridge area, five individuals of *P. densiflora* for. *erecta* occupied most of the upper crown-cover area, and number 12 of dead tree was difficult to find out the one of the dead types of Nakashizuka (1984) because the status of the tree was dark burned badly with the snapped bole off. Juvenile individuals of *P. densiflora* for. *erecta* under the 3 m of height were concentrated at the area between number 1 tree and 44 tree. The assembled distribution of juvenile trees were probably predicted to have been established by the gap formed after disturbance about 30 to 40 years ago, although the two individuals occupy the upper crown-cover area at present.

At site 4 investigated in the valley area, just 6 individuals (1, 2, 3, 4, 5 and 6) of *P. densiflora* for. *erecta* occupied most part of the upper crown-cover area. Hardwood species of *Q. mongolica, C. laxiflora, Q. serrata* and *A. pseudosieboldianum* were growing in the millde story about ten meters of height. The only individual of dead tree was looked like a kind of stem broken type. And a lot of seedlings and saplings of several species such as *Q. mongolica, S. alnifolia, M. amurensis, K. pictus, A. pseudosieboldianum, Q. serrata, A. mono* and *C. laxiflora* were discovered.

At site 5 investigated the upper slope area, *P. densiflora* for. *erecta* dominated all layers. Seedlings and saplings of *P. densiflora* for. *erecta* were more abundant as 19 individuals than those of *Q. mongolica* as 2 individuals. And they were also distributed in a gap area or an opened area.

At site 6 investigated in the middle slope area, just 5 individuals (1, 2, 3, 4 and 6) of *P. densiflora* for. *erecta* occupied most part of the upper crown-cover area. In the middle layer, *Q. mongolica*, and *P. densiflora* for. *erecta* occupied similar proportion, but the number of seedlings and saplings of *densiflora* for. *erecta* was the most abundant in this site among six sites. And there were three kinds of dead types such as standing dead type, uprooted type and stem broken type. That is, it was predicted that disturbance could frequently occur in this patch since the stand was established.

Growth pattern

Age distributions and growth rates of trees have been generally investigated by means of the stem analysis. It may be useful to clarify the history of the stand and/or of a single tree. Growth curves of planted coniferous trees were intensively studied by stem analysis in forestry (Watanabe 1983). In this research, Fig. 4 (c) and (d) showed growth curves of major individuals in competition relationships among them, which were able to explain the early growth patterns by accumulating the width of annual ring from pith to the last ring width of 1998 year and regression equation, respectively.

At site 1, the initial growth rate of pine trees occupying the upper crown was about ten times higher than that of two individuals of *Q. variabilis* which were 50 years old and 156 years old, respectively. The regression equation calculated from the 1, 3, 9 and 10 individuals growing well was $lnY=0.17+0.71\ lnX$ (R^2 was 0.92). The radial growth pattern of the individual (number 9) which was the oldest pine tree in this patch was shown in Fig. 4. The pattern reflected the history of growing environments which had been fluctuated for the entire period of life caused by fre-

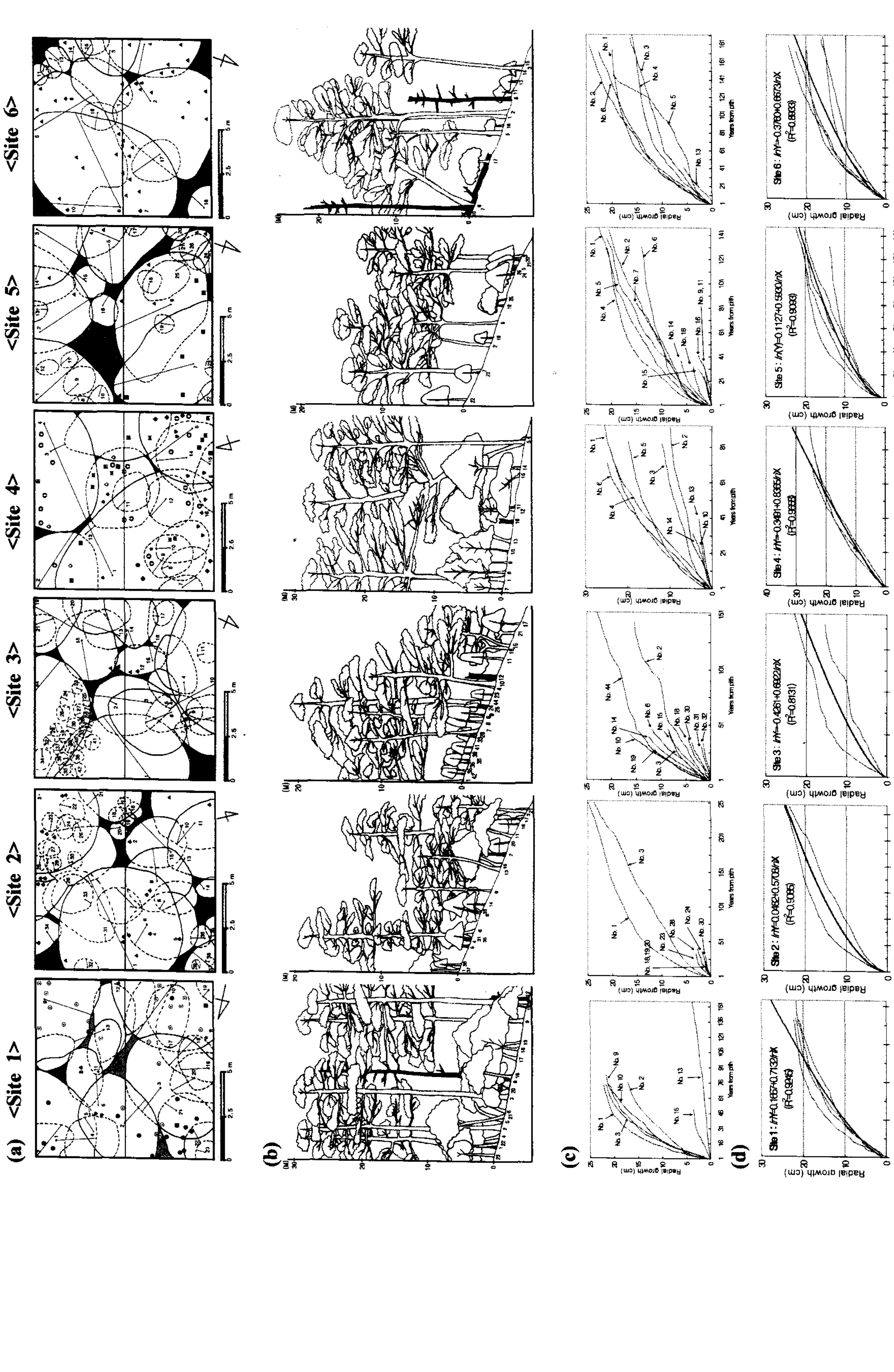


Fig. 4. Diagrams show the spatial distribution of individual trees and crown projection (a), stand profile (b), legends of individual trees (c), growth curves of major individuals in competiton relationships between each others showing the early growth patterns by accumulating the width of annual rings from pith to annual ring of 1998 (d), and graphs indicating growth curves (line) and regression lines (solid line) obtained by accumulating the width of annual rings from pith to the last ring of 1998 for major individuals of tree layer in the 6 studied sites(e), respectively.

(e)

No.	Species	Height (m)	DBH (cm)	Crown Height (m)
1	*P. densiflora* f. *erecta*	30	50	14
2	*P. densiflora* f. *erecta*	30	36	20
3	*P. densiflora* f. *erecta*	32	53	22
4	*Quercus mongolica*	9	12	2
5	*Q. mongolica*	7	7	4
6	*Q. mongolica*	6	6	3
7	*Acer pseudosieboldianum*	7	8	1
8	dead *P. d.* f. *erecta*	29+10	40	5
9	*P. densiflora* f. *erecta*	32	58	13
10	*P. densiflora* f. *erecta*	32	52	20
11	*Q. mongolica*	6	6	4
12	dead *P. d.* f. *erecta*	5	-	-
13	*Quercus variabilis*	8	13	5
15	*Q. variabilis*	5	8	3
16	*Q. mongolica*	8	9	5
17	*Q. mongolica*	10	13	6
18	*Styrax obassia*	8	10	2
19	*Q. mongolica*	5	5	2
20	*A. pseudosieboldianum*	4	5+3+2	1.5
21	*Q. mongolica*	12	14	6
22	*Q. mongolica*	6	5	4
23	*A. pseudosieboldianum*	6	6	4

■ : seedling and sapling of *Q. mongolica* : 4 individuals

◉ : seedling and sapling of *A. pseudosieboldianum* : 22 individuals

● : seedling and sapling of *Styrax obassia* : 16 individuals

★ : seedling and sapling of *Acer mono* : 2 individuals

♥ : seedling and sapling of *Carpinus laxiflora* : 2 individuals

♣ : dead *P. densiflora* f. *erecta* : 2 individuals

No.	Species	Height (m)	DBH (cm)	Crown Height (m)
1	*P. d.* for. *erecta*	20	50	12
2	dead *P. d.* f. *erecta*	9	46	-
3	*P. d.* f. *erecta*	20	58	10
4	dead *P. d.* f. *erecta*	1.5	50	-
5	dead *P. d.* f. *erecta*	2	50	-
6	*P. d.* f. *erecta*	12	18	5
7	*P. d.* f. *erecta*	7	8	2
8	*P. d.* f. *erecta*	7	8	4
9	*P. d.* f. *erecta*	11	16	3
10	*Quercus mongolica*	7	12	4
11	*Q. mongolica*	6	11	4
13	*P. d.* f. *erecta*	11	16	7
14	*P. d.* f. *erecta*	3	2	2
15	*Betula schmidtii*	8	11	3
16	*P. d.* f. *erecta*	5	6	4
17	*P. d.* f. *erecta*	4	5	3
18	*P. d.* f. *erecta*	4	4	3
19	*P. d.* f. *erecta*	4	4	3
20	*P. d.* f. *erecta*	3	3	2.5
21	*P. d.* f. *erecta*	10	12	5
22	*P. d.* f. *erecta*	7	8	4
23	*P. d.* f. *erecta*	4	5	3
24	*P. d.* f. *erecta*	4	4	3
25	*P. d.* f. *erecta*	4	5	3.5
26	*Q. mongolica*	6	14+9	3
27	*P. d.* f. *erecta*	5	5	4
28	*P. d.* f. *erecta*	3	2	2
29	*P. d.* f. *erecta*	3	2	2
30	*P. d.* f. *erecta*	4	3	3
31	*Q. mongolica*	6	8	2
32	*P. d.* f. *erecta*	4	4	3
33	*Q. mongolica*	3	6+4	1
34	*Q. mongolica*	5	7	3
35	*P. d.* f. *erecta*	4	3	2
36	*P. d.* f. *erecta*	4	5	2
37	*Q. mongolica*	7	5	4
38	*P. d.* f. *erecta*	4	2	3
39	*P. d.* f. *erecta*	3	2	2

♣ dead *P. d.* f. *erecta* : 19 individuals

▲ seedling and sapling of *P. d.* f. *erecta* : 7 individuals

No.	Species	Height (m)	DBH (cm)	Crown Height (m)
1	*P. d.* f. *erecta*	15	30	5
2	*P. d.* f. *erecta*	17	30	13
3	*P. d.* f. *erecta*	11	22	3
4	*P. d.* f. *erecta*	9	12	7
5	*P. d.* f. *erecta*	8	14	4
6	*P. d.* f. *erecta*	16	22	8
7	*P. d.* f. *erecta*	16	20	9
8	*P. d.* f. *erecta*	5	6	3
9	*P. d.* f. *erecta*	6	6	3
10	*P. d.* f. *erecta*	17	28	6
11	*P. d.* f. *erecta*	6	5	4
12	dead *P. d.* f. *erecta*	4	70	-
13	*P. d.* f. *erecta*	8	16	4
14	*P. d.* f. *erecta*	14	26	6
15	*P. d.* f. *erecta*	12	18	4
16	*P. d.* f. *erecta*	12	20	5
17	*P. d.* f. *erecta*	7	10	4
18	*Quercus mongolica*	9	10	5
19	*P. d.* f. *erecta*	9	20	3
20	*P. d.* f. *erecta*	9	11	6
21	*Q. mongolica*	6	9+5	3
22-43	*P. d.* f. *erecta*	3	3	1.5
44	*P. d.* f. *erecta*	23	47	12

♣ dead *P. d.* f. *erecta* : 1 individual

▲ seedling and sapling of *P. d.* f. *erecta* : 6 individuals

No.	Species	Height (m)	DBH (cm)	Crown Height (m)
1	*P. d.* f. *erecta*	28	55	14
2	*P. d.* f. *erecta*	18	31	10
3	*P. d.* f. *erecta*	24	30	12
4	*P. d.* f. *erecta*	30	58	14
5	*P. d.* f. *erecta*	30	43	18
6	*P. d.* f. *erecta*	26	56	12
7	*Carpinus laxiflora*	6	5	2
8	*C. laxiflora*	10	7	3
9	*C. laxiflora*	8	7	3
10	*C. laxiflora*	8	6	3
11	*C. laxiflora*	4	3	2
12	*Quercus mongolica*	11	8	5
13	*Quercus serrata*	12	11	7
14	*Q. serrata*	13	12	7
15	*Acer pseudosieboldianum*	3	4	1
16	dead *P. d.* f. *erecta*	1.5	60	-

■ seedling and sapling of *Q. mongolica* : 4 individuals

◎ seedling and sapling of *Sorbus alnifolia* : 21 individuals

♤ seedling and sapling of *Maackia amurensis* : 4 individuals

▣ seedling and sapling of *A. pseudosieboldianum* : 13 individuals

◆ seedling and sapling of *Q. serrata* : 5 individuals

♥ seedling and sapling of *C. laxiflora* : 7 individuals

● seedling and sapling of *S. obassia* : 6 individuals

♠ seedling and sapling of *Kalopanax pictus* : 3 individuals

★ seedling and sapling of *A. mono* : 1 individual

No.	Species	Height (m)	DBH (cm)	Crown Height (m)
1	*P. d.* f. *erecta*	14	51	10
2	*P. d.* f. *erecta*	16	44	7
3	*P. d.* f. *erecta*	17	52	8
4	*P. d.* f. *erecta*	14	46	7
5	*P. d.* f. *erecta*	15	36	8
6	*P. d.* f. *erecta*	11	30	7
7	*P. d.* f. *erecta*	15	39	9
8	*P. d.* f. *erecta*	6	10	3
9	*P. d.* f. *erecta*	5	6	2
10	*P. d.* f. *erecta*	5	7	2
11	*P. d.* f. *erecta*	1.5	3	0.5
12	*P. d.* f. *erecta*	2	3	1
13	*P. d.* f. *erecta*	3	4	2
14	*P. d.* f. *erecta*	7	13	3
15	*P. d.* f. *erecta*	3	6	1
16	*P. d.* f. *erecta*	2	3	1
17	*P. d.* f. *erecta*	2	3	1
18	*P. d.* f. *erecta*	2	4	1
19	*P. d.* f. *erecta*	1	4	0.5
20	*P. d.* f. *erecta*	4	8	1
21	*P. d.* f. *erecta*	4	7	1
22	*P. d.* f. *erecta*	6	13	2
23	*P. d.* f. *erecta*	2	8	1
24	*P. d.* f. *erecta*	3	6	1
25	*Quercus mongolica*	2	5	0.5
26	*Q. mongolica*	2	4	0.5

▲ seedling and sapling of *P. d.* f. *erecta* : 19 individuals

■ seedling and sapling of *Q. mongolica* : 6 individuals

No.	Species	Height (m)	DBH (cm)	Crown Height (m)
1	*P. d.* f. *erecta*	20	41	15
2	*P. d.* f. *erecta*	25	48	10
3	*P. d.* f. *erecta*	23	37	16
4	*P. d.* f. *erecta*	23	39	9
5	*P. d.* f. *erecta*	14	36	6
6	*P. d.* f. *erecta*	23	62	7
7	dead *P. d.* f. *erecta*	20	-	17
8	dead *P. d.* f. *erecta*	14	-	4
9	dead *P. d.* f. *erecta*	23	-	8
10	dead *P. d.* f. *erecta*	-	-	-
11	*P. d.* f. *erecta*	2	3	1
12	*P. d.* f. *erecta*	2	5	1
13	*P. d.* f. *erecta*	2	5	1
14	*P. d.* f. *erecta*	1	3	0.5
15	*P. d.* f. *erecta*	2	4	1
16	*Quercus mongolica*	2	3	1
17	*Q. mongolica*	3	3	1
18	*Q. mongolica*	3	8	1

▲ seedling and sapling of *P. d.* f. *erecta* : 52 individuals

♣ dead *P. d.* f. *erecta* : 4 individuals

Fig. 4. (continued).

quent disturbance. And the annual growth width showed the tendency of the rapid decrease as time passing by.

At site 2, the initial growth rate of pine trees (number 1 and 3) occupying the upper crown was much faster than that of individuals (number 23, 24, 28 and 30) growing in under layer. Such results reflected that the environments at that time of the occurrence of the matured trees were more suitable for growing than those suppressed at the present by the trees of upper layer. It was also coincided with the consideration of Kim and Song. (1995). The regression equation calculated from the 1 and 3 individuals showing good growth was lnY=0.05+0.57lnX(R^2 was 0.91). The radial growth pattern of the individual (number 2) which was the oldest pine tree as 253 years old was shown in Fig. 4. The pattern reflected the history of growing environments which had been a little fluctuated for the entire period of life but had kept continually the growth width of 0.5 mm for about 200 years before 1998.

At site 3, the initial growth rate of the matured pine trees (number 2 and 44) occupying the upper crown showed the similar tendency to the individuals of pine trees (number 3, 6, 10, 14, 15 and 19) but it showed the dissimilar tendency to the trees (number 30, 31 and 32) which were growing slowly in the closed crown area. The present result was regarded as a little different one compared with researches which Kim and Song (1995) had carried out. Therefore, it was judged that the matured trees would be established under as the same environments as those of individuals of the pine trees (number 3, 6, 10, 14, 15 and 19) at present in this patch. The regression equation calculated from the 2 and 44 individuals growing well was lnY=0.43+0.69lnX (R^2 was 0.81).

At site 4, we need to observe carefully the growth pattern of the pine trees (number 1, 3 and 4). The growth patterns of those pine trees showed the similar trends for the first 10 years, but after then, the individual 3 of pine tree became to grow very slowly instead of the others keeping on their trends. Most deciduous trees distributed in the middle and under layers were in the situation of competition, and their growth rate showed the limitation in the individuals such as number 10, 13 and 14. The regression equation calculated from the 1, 4 and 6 individuals growing well was lnY=-0.35+0.84lnX (R^2 was 0.97).

At Site 5, the speed of initial growth of the matured pine trees (number 1, 2, 4, 5 and 7) occupying the upper crown showed mainly a little more fast trends than to the juvenile individuals of pine trees (number 14, 15, 16 and 18). The regression equation calculated from the 1, 2, 4 and 5 individuals growing well was lnY=0.11+0.59lnX (R^2 was 0.91). The radial growth pattern of the individual (number 5) which was the oldest pine tree in this patch was shown in Fig. 4. It was considered that this pattern could describe typical tendency for growth environments affected by several disturbances such as forest fire and others.

At Site 6, the speed of initial growth of the matured pine trees (number 1, 2, 3, 4, 5 and 6) occupying the upper crown showed almost the same tendency compared with the juvenile individual of pine tree (number 13). In which, the growth curve of number 5 tree fluctuated on times passing by, although it shows good growing at the present. The regression equation calculated from the 2, 3, 4 and 6 individuals growing well was lnY= 0.38+0.67lnX (R^2 was 0.89). The radial growth pattern of the individual (number 5) which was the oldest pine tree (192 years old) in this patch was shown in Fig. 4. And the growth of the tree was nearly in the situation stopped for several decades before now.

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