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Ecological Characteristics and Distribution of Plant Resources of *Pyrus* and *Malus sp.* in Jindong Valley, Gangwon Province

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ABSTRACT

Four major naturally populated areas around the Jindong valley in Inje-Gun, Gangwon province for wild *Pyrus ussuriensis*, *Malus sieboldii*, and *Malus baccata* are mostly located on the southeast side of the mountains at 630-745m in altitude at sea level and are in very good sunny areas. The total of 77 taxa dividing into 32 families, 58 genera, 65 species, and 12 varieties has been inhabited in these areas. Most of these plants are heliophytes, which love sunshine, but some of rhizo-plants such as *Sasa borealis*, climbing plants such as *Actinidia arguta* and *Celastrus orbiculatus*, or naturalized plants like *Bidens frondosa* are also shown. These areas have been continually destroyed, so it is possibly thought that the second transition has been progressed. The index of species diversity of plant groups in these areas is 0.672~1.465 based on the Shannon-Wiener's method, but its index for the area that rhizo-plants like *Sasa borealis* are growing as an under planting decreases relatively. In this study, the oldest plant of *Pyrus ussuriensis* in Korea, which is 120cm in diameter at breast height (DBH), 19m in tree height and 25m in width, has been found.

Key Words : *J*indong valley, *Pyrus, Malus*, heliophytes, naturalized plants, species diversity, genetic resources

INTRODUCTION

Apples and pears are major deciduous fruit trees cultivating everywhere in South Korea except Jeju-Do. Because flowers and leaves, as well as fruits of those trees can be appreciative, they are very good natural ornamental plants. The qualities of apples and pears produced in Korea are excellent in terms of fruit texture and flavors because our country is located in the northern part of the temperate zone where the quality of fruits are generally good. Most pear trees cultivated in Korea came from Japan since Japanese breeders have developed many cultivars (Kim et. al., 1988). Most apple trees cultivated everywhere in Korea except Jeju-Do also came from either Japan or America. Nevertheless, it has been continually required to develop many good cultivars against many plant diseases, and also to develop good ornamental fruit trees with beautiful flowers and leaves, as well as edible fruits. In order to develop excellent cultivars through breeding, many varieties of wild genetic resources for these fruit trees containing many useful genes should have been retained first. Because seeds of these fruit trees are easy to germinate and these plants have very strong tree vigor, fruit seeds are generally sown and young plants have been directly used as rootstocks for grafting (Moore, 1983). But some wild varieties have

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beautiful flowers and leaves, and the quality of their fruits is excellent. Even though our country is located in the northern part of the temperate zone, however, not many research to study the distribution of wild plants and their physiological and morphological characteristics have been conducted actively (Ahn, 1997). In the war of plant resource in 21st century, therefore, lots of studies of wild genetic resources distributed in our country have been required.

The wild *Pyrus* plants belong to the deciduous woody plants in Rosaceae family. About 30 species of those plants have been known to be cultivated all over in Europe and Asia, and some area in Africa. Most are cultivated for fruit productions, but some for ornamental plants. There are 5 *Pyrus* species including *Pyrus ussuriensis* and 8 varieties cultivated in Korea. Especially *Pyrus ussuriensis* is naturally inhabited in southeast Siberia, east China and Korea. In Korea, these plants are populated near villages or on hills, and they are easily propagated since their fruit are very juicy and quite big in size. The big pear named "White Pear" cultivated in China and Japan has been developed from this species (Hotta, 1989), *Pyrus ussuriensis*. Because the basic haploid chromosome number of all *Pomoidae* genera is 17 (Westwood, 1993), most *Pyrus* plants have 34 in the diploid chromosome number. Plant breeding to get improved cultivars is not difficult because the *Pyrus* plants are easy to cross breeding among its genus. Because not only this reason but there have been shown lots of variation in wild groups, the *Pyrus* plants inhabited in Korea are excellent deciduous woody plants and favorable fruit trees to develop ornamental plants (Dirr, 1990). The *Malus* plants are also populated in the temperate zone in the northern hemisphere and important as ornamental plants. There have been 25 genera around the world and 5 genera including *Malus baccata* and 3 cultivars growing in Korea (Lee, 1979). Among them, *Malus baccata* and *M. sieboldii* are easy to find out everywhere on the hill, and they have strong physiological characters to survive. Because their flowers and fruits are showing excellent ornamental characters, these plants have been used as garden trees without improving.

Jindong valley where the major examination has been done is one of the valleys located in Kirin-Myon, Inje-Gun, Gangwon province, and is the main entrance for hiking Jumbong Mountain. This area is the core area for the natural environment located in mid-northern Korea, and flora of this area is very diverse because of one of the major forest areas in Korea, where factors for the northern temperate climate are distributed along Taebaek Mountain Range to southward (Kim and Kim, 1995). Because of this reason, therefore, flora of this area has been known to be very sufficient. According to Jeon et. al. (1997), the total of 456 taxa divided into 87 families, 224 genera, 376 species, 70 varieties, 6 cultivars, 4 hybrids has been reported to inhabit in Jumbong Mountain.

It is necessary to develop many kinds of fruit trees and ornamental trees containing genetically different character, so that it will be satisfied for many different people' s taste and demands. Collecting lots of wild plant resource with diverse genes is necessary for plant breeding. The purpose of this study is to analyze ecological characteristics and to show diversities of the wild *Pyrus* and *Malus* plants around Jindong valley in Gangwon province because the flora is diverse, and the result will provide a useful reference to use wild plant resource effectively in future.

MATERIALS AND METHODS

Our investigation has been carried out for three months from June 1, 2001. The major investigation has been focused on areas where could be possibly approached within about 30km elevating along Jindong valley located in Kirin-Myon, Inje-Gun, Gangwon province. The survey was started from the naturally

Table 1. Description of physical features and stratum of each plot in *Pyrus ussuriensis*, *Malus sieboldii* and *Malus baccatadii* habitat

Habitat / Plot Number	Ⅰ	Ⅱ	Ⅲ	Ⅳ
Latitude	N37° 59′ 04.9″	N37° 59′ 27.4″	N38° 01′ 59.8″	N38° 01′ 26.8″
Longitude	E128° 29′ 33.1″	E128° 29′ 35.1″	N128° 28′ 31.6″	N128° 28′ 03.7″
Altitude (m)	630	635	743	745
Expostion	NE	SE	SE	NW
Light intensity	Sunshine	Sunshine	Sunshine	Sunshine
Slop ( )	46	55	0	40
Height of tree layer (m)	12	10	19	17
Cover of tree layer (%)	30	10	50	40
Height of subtree layer (m)	5	5.5	3	6.5
Cover of subtree layer (%)	20	20	10	20
Height of shrub layer (m)	1.2	2.5	2	1.8
Cover of shrub layer (%)	30	30	10	
Height of herb layer (m)	0.6	0.6	0.8	0.8
Cover of herb layer (%)	50	50	60	60
Depth of soil (Ao : cm)	10	10	20	20

Table 2. The climatic factors of surveyed areas (Inje-Gun : 1993 - 2000)

Month / Factor	1	2	3	4	5	6	7	8	9	10	11	12	Annual
Mean Temp. (℃)	-2.5	-2.0	4.3	10.9	15.7	21.1	24.0	23.4	19.2	12.0	4.8	-1.2	10.8
Max. Temp (℃)	9.6	9.0	18.8	26.1	29.8	33.9	34.3	34.2	31.6	25.4	20.2	11.8	23.7
Min. Temp (℃)	-16.0	-15.8	-8.1	-3.0	4.2	10.7	14.7	17.0	9.7	-1.9	-8.6	-15.0	-1.1
Rel humidity (%)	61.0	55.5	54.0	54.0	64.0	65.0	73.0	76.0	73.5	71.5	66.0	62.5	64.7
Precipitation (mm)	17.5	3.9	28.0	60.2	94.1	85.2	224.3	493.6	223.8	51.6	16.4	21.0	110.1
% of Sunshine	57.5	57.0	49.5	49.5	41.0	46.0	32.0	32.0	35.0	41.0	43.5	44.0	7.0
Frost day	20.2	19.0	15.0	5.0	0	0	0	0	0	2.5	8.5	14.5	44

inhabited spot of *Pyrus* genera and *Malus* genera within 200m radius of a circle in terms of ecological characters. The enumeration district is shown in a Table 1. The survey for vegetation was conducted according to the Braun-Blanquet Method (1964) which the cover degree and sociability of the specific plant genera emerging within a 20 x 20m quadrat. In each quadrat, a tree layer, a subtree layer, a shrub layer and an herb layer were divided first, and then the percent vegetation of each layer was investigated. To evaluate the vegetative group in the surveyed area, the degree of diversity and the aspects of an ecological propagation of each genus were analyzed, and then the soil characteristics was also analyzed from each soil sample collected from those areas. The latitude and longitude, and the altitude at sea level have been measured by using Global Positioning System (GPS-Ⅲ)

Table 3. The list of plants in *Pyrus ussuriensi*, *Malus sieboldii* and *Malus baccatadii* habitat.

Family name	Scientific name	survey plot
Pteridaceae	*Pterridium aquilinum* var *latiusculum*	2
Aspidiaceae	*Athyrium yokoscense* H. Christ	3
	Athyrium niponicum (Mett,) Hance	3,4
	Dryopteris crassirhizoma Nakai	4
	Matteuccia struthiopteris(L) Todard	1
Gramineae	*Sasa borealis* Makino	3.4
	Setaria viridis (L) Beauv.	1
	Setaria glauca (L) Beauv.	1.2
	Miscanthus sinensis Anderss	3
Cyperaceae	*Carex lanceolata* Boott	1
	Carex siderosticta Hance	1
	Carex bostrychostigma Max.	1
Commelinaceae	*Commelina communis* L.	2
Salicaceae	*Salix pseudo-lasiogyne* Lev	2
	Salix gracilistyla Miq	1
Betulaceae	*Corylus heterophylla* var. *thunbergii* bl.	1
Fraganceae	*Quercus serrata* Thunb	1
	Quercus mongolica Fisch	1
Ulmaceae	*Ulmus davidana* Planch	3
	Ulmus laciniata (TRAUTV.) Mayr	1
Polygonaceae	*Persicaria thunbergii* H. Gross	2
	Persicarica sieboldii Ohki	3
	Persicaria lapathifolia S.F. Gray	3
	Polygonum aviculare L.	3
Chenopodiaceae	*Chenopodium album* var. *centrorubrum* Makino	2
Ranunculaceae	*Clematis apifolia* A.P. DC.	2
	Aconitum villosum Reichb.	3
Lauraceae	*Lindera obtusiloba* Bl	1
Fumariaceae	*Corydalis speciosa* Max	4
	Corydalis gigantea var. *Macrantha*	2
Rosaceae	*Sorbaria sorbifolia* var. *stellipila*	2
	Rubus crataegifolius Bunge	1.2.3.4
	Rubus oldhamii Miq	3
Leguminosae	*Lespedeza cyrtobotrya* Miq.	1
	Vicia amoena Fisch	1
	Amphicarpaea edgeworthii var. *tris-perma* Ohwi	2
	Trifolium repens L.	2

Family name	Scientific name	survey plot
Celastraceae	*Euonymus alatus* (THUNB) SIEB	1
	Celastrus orbiculatus THUNB	2.3
	Tripterygium regelii SPRAGUE et TAKEDA	3.4
Aceraceae	*Acer ginnata* MAX	1.2.3
	Acer ginnala MAX	1.2.4
	Acer pseudo-sieboldianum KOM	1
Tiliaceae	*Tilia amurensis* RUPR	1
Actinidiaceae	*Actinidia arguta* PLANCH	1.2.3
Violaceae	*Viola diamantica* NAKAI	2.3
Violaceae	*Viola acuminata* LEDER	2
Onagraceae	*Epilobium pyrricholophum* FR. et SAV	3
Umbelliferae	*Sium suave* WALTER	1.3
	Angelica polymorpha MAX	3
Cornaceae	*Cornus controversa* HEMSL.	1.2
Primulaceae	*Lysimachia clethroides* DUBY	3
Styracaceae	*Styrax obassia* S. et. Z.	1
	Styrax japonica S. et Z.	1
Oleaceae	*Fraxinus rhynchophylla* HANCE	1.2.3.4
Labiatae	*Prunella vulgaris* var. *lilacina* NAKAI	1.2
	Elsholtzia ciliata (THUNB.) HYLANDER	3
Phrymaceae	*Phryma leptostachya* var. *asiatica* HARA	3
Valerianaceae	*Valeriana fauriei* BRIQ	3
Caprifoliaceae	*Sambucus williamsii* var *coreana* NAKAI	3
Compositae	*Ainsliaea acerifolia* SCH-BIP	1
	Splidago virga-aurea var *asiatica* NAKAI	2.3
	Aster tataricus L.	1.2
	Aster ciliosus KITAMURA	1
	Erigeron annuus (L.) PERS	2
	Petasites japonica MAX	2
	Achillea sibirica LEDEB	1
	Chrysanthemum boreale MAKINO	1
	Aretemisia capillaris THUNB.	1.2
	Artemisia japonica THUNB	1.2
	Artemisia keiskeana MIQ.	1
	Picris hieracioides var. *glabrescens* OHWI	1
	Artemisia princeps var. *orientalis* (PAMPAN.) HARA	3
	Bidens frondosa L.	2.3
	Cricium setidens NAKAI	3
	Saussurea pulchella FISCH	2
	Youngia denticulata KITAMURA	1.2

Table 4. Various species diversity of surveyed plots in *Pyrus ussuriensis*, *Malus sieboldii* and *Malus baccatadii* habitat

Habitat plot No.	No. of species	No. of total individual	Shannon-Wiener' s species diversity (H')	Maximum of species diversity (H' Max)	Evenness (J')	Domonance (D)
Ⅰ	41	263	1.465	1.613	0.908	0.092
Ⅱ	30	160	1.329	1.477	0.900	0.100
Ⅲ	32	364	1.307	1.505	0.868	0.132
Ⅳ	11	137	0.672	1.041	0.646	0.354

Table 5. Distribution of mean DBH classes of *Pyrus ussuriensis*, *Malus sieboldii* and *Malus baccatadii* habitat

Habitat Plant No	species	D1*	D2	D3	D4	D5
Ⅰ	*Pyrus ussuriensis*	2	4	3	1	0
	Malus sieboldii	2	3	7	0	0
	Malus baccatadii	0	2	0	0	0
Ⅱ	*Pyrus ussuriensis*	0	0	4	1	0
	Malus sieboldii	0	0	0	0	0
	Malus baccatadii	0	0	0	0	0
Ⅲ	*Pyrus ussuriensis*	2	5	4	1	1
	Malus sieboldii	2	5	3	0	0
	Malus baccatadii	1	2	0	0	0
Ⅳ	*Pyrus ussuriensis*	0	4	2	2	0
	Malus sieboldii	3	2	0	0	0
	Malus baccatadii	2	0	0	0	0

D* : DBH (cm) ; D1 : 0 ~ 10cm, D2 : 11 ~ 20cm, D3 : 21 ~ 50cm, D4 : 51~100cm, D5 : over 100cm

and a digital altimeter (Pretel Alti-D2). The soil pH and humidity were measured on the spot by using a simple combined type of pH and hygrometer (Takemura Electro DM-15). The degree of the soil hardness was measured by using a penetrative soil hardness meter (Yamanaka K-730). The light intensity in the colony area was measured by using a portable photometer (Delta OHM HD-8366). The annual climatic change of Jindong valley has been analyzed using climatic data of Inje-Gun between 1993 and 2000.

Each soil sample from four naturally populated areas for *Pyrus* genera and *Malus* genera groups was collected and pretreated as follows in order to examine soil characteristics. The soil samples were spread onto a clean vinyl sheet in the room and air dried for 10 days at 25~35 until the range of water content is 20~60%. Each soil sample was filtered through a 2mm-sieve to remove sands or pebbles. These prepared samples were used to analyze for pH, EC (electric charge), OM (organic materials), CEC (cation exchange capacity), P_2O_5, K^+, Ca^+, Mg^{+2}, and Na^+. Each value of EC, OM, CEC and P_2O_5 is measured according to the conductivity method (Jung, 2000), the Turin method (Jung, 2000), an 1N-ammonium method in substitution leaching methods (Jung, 2000), and the Troug method (Jung, 2000) accordingly.

Table 6. Physical and chemical properties of the soil in each surveyed plot for *Pyrus ussuriensis*, *Malus sieboldii* and *Malus baccatadii* habitat

Plot	Soil pH	EC (ds/m) 23	Organic matter (%)	Total nitrogen (%)	Available phoshate (ppm)	Cation excange capacity (mol/l)	Exchangeable cations (mg/l)			
							Ca	K	Mg	Na
I	5.31	0.16	13.9	4.444	40.70	16.4	27.95	4.947	2.633	1.433
II	5.35	0.57	7.17	14.20	130.07	20.3	51.26	25.67	5.342	6.180
III	5.46	0.28	16.03	8.522	78.06	24.2	49.97	28.55	7.294	1.361
IV	5.92	0.86	6.5	6.954	63.69	40.2	425.1	19.55	45.20	1.533

RESULT AND DISCUSSION

From data shown in Table 1, the major populated area for wild *Pyrus ussuriensis*, *Malus sieboldii*, and *Malus baccata* that we surveyed are mostly located at 630-745m in altitude at sea level. The direction of the side of cultivating area is southeast where is always sunny during daytime. The most of theses areas are very steep, about 40-50in gradient, except for few plain spots. The coverage of herb layer in this area is shown 50-60%. Our result shows that, however, the coverage of woody plants of 10-19m in tree height is 10-50%, so that it is relatively low comparing to the coverage of herbs (Fig. 1). Because the coverage of woody plants is so low that tall woody plants in the populated area do not shade, it is thought that wild *Pyrus ussuriensis*, *Malus sieboldii*, or *Malus baccata* as a heliophyte have an advantage for their vegetation (Stebbins, 1976). The annual climatic change of Jindong valley has been analyzed to show climatic factors in Table 2 based on climatic data of Inje-Gun from 1993 to 2000.

There is the total of 77 taxa dividing into 32 families, 58 genera, 65 species, and 12 varieties found around the spot of naturally populated wild *Pyrus ussuriensis*, *Malus sieboldii*, or *Malus baccata* in Jindong valley (Table 3). Xylophytes including *Fraxinus rhynchophylla*, *Acer ginnala*, *Acer mono* and *Cornus controversa*, herbs such as *Solidago virga-aurea* var. *asiatica*, *Aster tataricus*, *Artemisia capillaris*, *Artemisia princeps* var. *orientalis* and *Sasa borealis*, or climbing plants such as *Actinidia arguta* and *Celastrus orbiculatus* have been appeared. Because a large number of heliophilous plants especially *Artemisia sp.* or naturalized plants such as *Bidens frondosa* have been appeared, we assumed that those areas have been continually destroyed even though it is not determined what kinds of destruction has been occurred. According to Song and Kim (1993), the coverage of *Artemisia capillaris* and *Artemisia princeps* var. *orientalis* in the partially dried area that is severely destructed for a dam construction is very high in percentage. Appearing a large number of aggressively propagated climbing plants such as *Actinidia arguta* or *Celastrus orbiculatus* supports our result. Based on this result, most species naturally inhabited around wild *Pyrus ussuriensis*, *Malus sieboldii*, or *Malus baccata*, which are the major surveyed plants, are heliophytes. So it is suggested that those are the plant groups that the second transition has been progressed actively at present. On the front face of the wild vegetative areas, most plants are heliophytes that can grow in dried condition, but plants growing in the wild vegetative areas near the valley are helophytes because the soil contains lots of moisture. According to the phytosocialogical vegetation of Baekhwa Mountain (N36° 16' 00", E127° 56' 30") studied by Cho et. al.

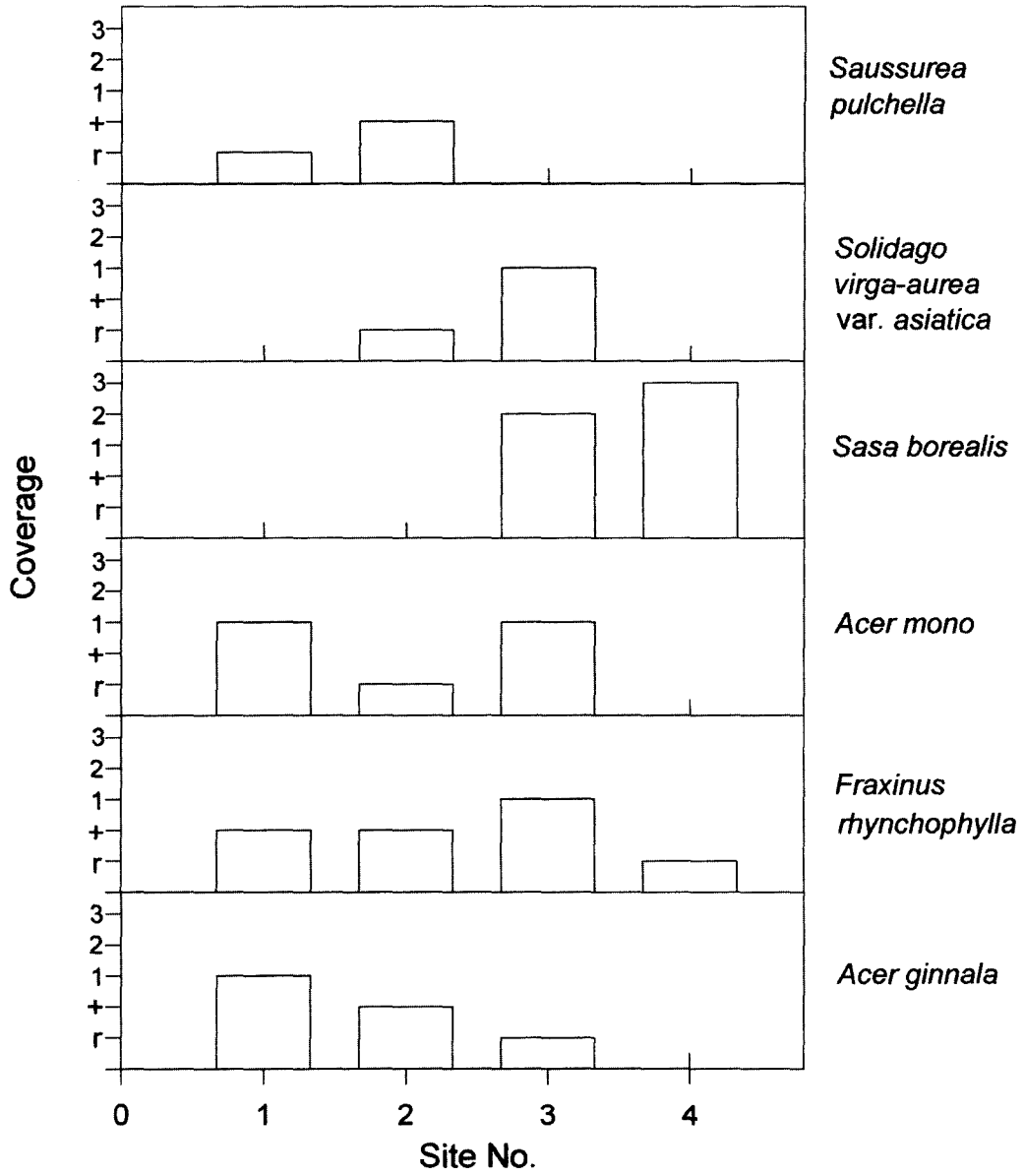

Fig. 1. Coverage of the major plant species in *Pyrus ussuriensis*, *Malus sieboldii* and *M.baccatadii* habitat

(1991), *Fraxinus rhynchophylla-Acer ginnala* community, a tree layer including *Fraxinus rhynchophylla*, *Acer ginnala*, *Cornus controversa*, *Acer pseudo-sieboldianum* and *Platycarya strobilacea*, herbs such as *Phryma leptostachya* var. *asiatica* and *Impatiens textori*, and climbing plants such as *Actinidia polygama*, *Rubus crataegifolius* and *Parthenocissus tricuspidata* are generally populated around the area located at 600m in altitude at sea level with 18 in slop, and these are very similar to our result shown in this paper.

Table 3 also shows the result for the structure of plant communities in the major wild populated areas for wild *Pyrus ussuriensis*, *Malus sieboldii*, or *Malus*

baccata where we studied. In each surveyed area, 11 genera and 41 species in average have been appeared. The frequency of appearing species in the surveyed area 3 was quite low because, from our points of view, the species have been simplified since the groups of *Sasa borealis* in lower parts of the herb layer has been developed widely. The index of species diversity of plant groups in these areas is 0.672~1.465 based on the Shannon-Wiener' s method (1949). The index of species diversity in the surveyed area 3, where the groups of *Sasa borealis* are developed, is relatively low comparing to other areas. The total number of species in the surveyed area 1 is 41 and the total number of individual plants appeared is 263, so the index of species diversity in the area 1 is 1.613 which is relatively higher.

The distribution for various DBH of wild *Pyrus ussuriensis*, *Malus sieboldii*, or *Malus baccata* naturally populated in each surveyed area is shown in Table 4. There are 10 plants studied in the surveyed area 1. Two plants out of them are 0-10cm in DBH, 4 plants are 11-20cm, 3 plants are 21-50cm and 1 plant is above 51cm. In the same area, 12 *Malus sieboldii* were surveyed. The DBH of 7 plants is 21-50cm, but any plant with above 51cm has not been found. Only 2 *Malus baccata*, which are 11-20cm in DBH, have been found in the same area. Especially in the area 3, 18 *Pyrus ussuriensis* including one plant with above 50cm in DBH and another one with even above 100cm in DBH were found. The wild *Pyrus ussuriensis* with 120cm in DBH surveyed in the area 3 is 19m in tree height and 25m in width, so that it is the oldest and biggest one among old and big wild Pyrus ussuriensis being surveyed in South Korea. Therefore, we strongly suggest that these plants must be assigned by the government as natural monuments or nurse trees.

The characteristics of the soil in the major populated area for wild *Pyrus ussuriensis*, *Malus sieboldii*, or *Malus baccata* have been analyzed and shown in Table 5. The average of the soil pH in these areas is 5.31-5.92, so it is slightly acid. EC is in the range of 0.16-0.86ds/m, and OM is variable in each area, 6.5-16.03%. Especially in area 2 and 4 where the degree of slope shows high, the values of OM are relatively low because leaching of organic matters in the steep area is very high when it rains. CEC of these areas is 16.4-40.2mol/kg in average. There is no significance according to cation content analyses for, K^{+}, Ca^{+}, Mg^{+2}, and Na^{+}, but the value for Ca^{+} content in the area 4 is especially high comparing to the values for other areas. Depth of soil layer in the surveyed areas. which contains organic material, is 10-20cm (data not shown).

Based on results from our research, wild *Pyrus ussuriensis*, *Malus sieboldii*, or *Malus baccata* are mostly populated in very good sunny areas and are competing with lots of climbing plants or actively developed rhizo-plants at present. Because of these reasons, these plants must be protected or managed by the government in order to keep our genetic resources for plants. Especially old and big trees that we surveyed must be protected through the special low.

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