Structural Characteristics and Maintenance Mechanism of *Ulmus pumila* Community at the Dong River, Gangwon-do, South Korea

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ABSTRACT : To analyze ecological characteristics of the Ulmus pumila community, an on-the-spot survey was conducted in August, 1998 in the Dong River, Gangwon-do, South Korea. The Ulmus pumila community is partially distributed in Dong River's midstream and upper stream. Topographical characteristics of this community are significant in the point bar or sandbank of the river. The community is classified into two types, disturbed and non-disturbed types, by the effect of flooding. The Ulmus pumila community (bush forests of Siberian elms) is a representative community which forms riparian forests, but its distribution is rare in South Korea. Only in Dong River is the Ulmus pumila distributed enough to form a community, and none is known that is lager than this community in South Korea. The non-disturbance type progresses more homogeneously than the disturbance type because it is formed on riverside banks where it is affected less by flooding. We concluded that the Ulmus pumila community in this study area has characteristics of riparian forests. In South Korea, Ulmus pumila community can be regarded as important element of vegetation landscape constituting riparian forests. Specifically, these riparian forests are evaluated as high in conservation value due to their being formed spontaneously. Moreover, Dong River is regarded as the southern limit of Ulmus pumila, which has a northern origin. The species or community needs continuous interests and conservation countermeasures because there are limitations in its spread of distribution by natural or artificial efforts.

Key words : Disturbance type, Dong River, Non-disturbance type, Riparian forest, *Ulmus pumila* community

INTRODUCTION

Ulmus pumila is mainly distributed in China, Mongolia, Korea, Russia, Central Asia, Central America and South America (Fu *et al.* 2003, Shermam-Broyles 1997). In particular, it is known to thrive on slopes, valleys, and plains within a 1,000~2,500 m range above sea level in Gansu, Hebei, Henan, Heilongjiang, Jilin, Liaoning, Nei Mongol, Ningxia, East Qinghai, Shandong, Shanxi, Sichuan, Xinjiang, and Xizang, China (Fu *et al.* 2003). In Korea, the tree is distributed to the north of Mt. Baengnyangsan, Jeollanam-do and Mt. Jirisan, Gyeongsangnam-do (Lee 1996). Some reports have described the species in the flora of Mt. Sobaeksan (Lee *et al.* 1995), Mt. Geumsusan (Kim and Han 1999a), Mt. Songnisan (Kang and Kwak 1998), Mt. Palgongsan (Kim and Eo 1998), Mt. Wolchulsan (Lee *et al.* 1989), Gogunsan Islands (Lee *et al.* 1981), Cheongsando Island (Lee *et al.* 1980), Seonunsan (Kim *et al.* 1988), and Keojedo Island (Kim 1996). But there are some uncertainty because there have been no voucher specimen gathered. Moreover, there is no information on that *Ulmus pumila* has been found along the communities in the area, except along the Dong River.

Riparian forest ecosystems received growing attention since the latter part of the 1980s because of the great importance for the understanding the underlying factors that influence vegetation patterns and species distribution (Forman and Godron 1986, Malanson 1993, Brown *et al.* 1997, Decocq 2002). In Korea, most riparian ecosystems have disappeared, and those remaining are declining in number. The rapid decline of these valuable ecosystems has made riparian conservation a focal issue in the public eye (Lee and You 2002).

Recently *Ulmus pumila* was found as communities along the Dong River (Kim and Han 1999b, Choung and Yang 1999). However, there was no synecological research to back up that information until today. Therefore, this research was carried out to analyze the ecological characteristics of the *Ulmus pumila* community found along the Dong River area.

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MATERIALS AND METHODS

Study area

The Dong River runs along the west of the Taebaeksan Mountains, which is known as the backbone range in the Korean Peninsula. The River is Namhan River's upper stream and rises in Mt. Odaesan vicinity (Fig. 1). Its topographical features include a V-type steep slope due to the surrounding steep topographical conditions. The river is partly deep and display bed structure allowing much gravel to accumulate because of its incised meander. Likewise, the cliff, point bar, pool, riffle, river terrace, flood plain, folding, cave, fault, tectonic alignment, and valley structure vary in form and scale for both sides of the river (Hong and Yu 1999). The units of the Joseon supergroup consisting of Cambrian-Ordovian limestone in the river area spread extensively at the bottom. The Pyeongan supergroup of the Carboniferous period and the Bansong group of the Jurassic period, among others, are buried below. Therefore, this area attracts scholars' interests in its geographical, geological, and ecological conditions.

The area along the Dong River shows the characteristics of continental climate. Its diurnal and annual ranges are also extensive. According to the climate data (Korea Meteorological Administration, http://www.kma.go.kr) of the Jecheon area adjoining the Dong River, the annual mean temperature from 1971 to 2000 is 10.0˚C, and the mean air temperature is −5.3˚C in January and 23.7˚C in August.

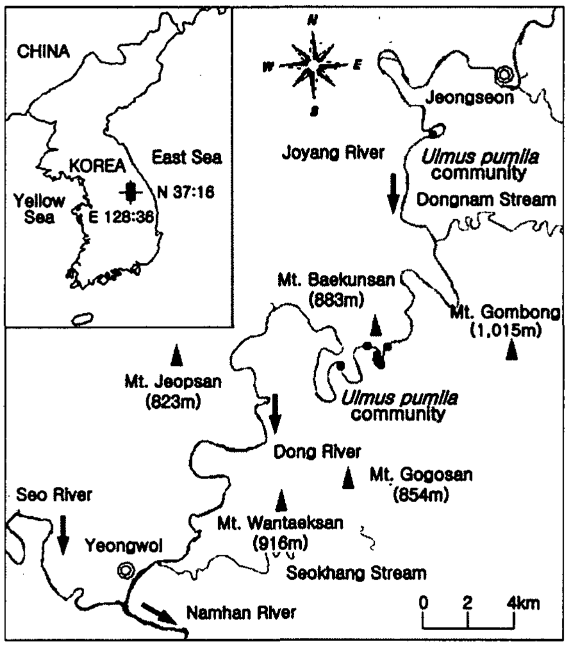

Fig. 1. Map showing the location of Dong River and *Ulmus pumila* community.

In addition, its average precipitation is 1,295.1 mm, exceeding the national precipitation average of 1,273 mm. In summer, its precipitation rises as high as 586.4 mm.

Field survey and data analysis

The on-the-spot survey was conducted twice (August 1998 and September 2002) in Dong River. The traditional phytosociological investigation (Braun-Blanquet 1964) was conducted to determine the structural characteristics of the *Ulmus pumila* community. The relevé is collected all 7. The diameter at breast height (DBH) of *Ulmus pumila* was measured in every relevé. Plant names were recorded in order, using Lee's illustrated book (1999). A profile of its vegetation was rearranged indoors after the on-the-spot sketch. In the meantime, an ordination technique called detrended correspondence analysis (DCA) was done (Hill and Gauch 1980) (PC-ORD ver. 2.0, MJM software) to compare the floristic composition of the *Ulmus pumila* community by topography on the basis of 7 relevés collected.

RESULTS

The *Ulmus pumila* community is partially distributed along the Dong River's midstream and upper stream. The topographical characteristics of this community at the point bar of the river and at the riverside sandbank are varied (Fig. 2). When the community is rare and the scale of the community is small, it ranges from 100~5000㎡. In case there is no visible community, the tree grows sporadically through the river. The community is divided into the disturbance type and the non-disturbance type according to influence of flooding (Fig. 3), *i.e.*, the disturbance type is formed at the point bar that sinks when there are floods. The non-disturbance type forms along the sand banks of the riverside that are not significantly affected by floods.

The vegetation height of the disturbance-types of *Ulmus pumila* community is 6∼7 m, with the coverage of a tree-1 layer 40∼60%. The community is mostly a two-story structure, with low herb layer coverage (20∼30%). There are few individual *Ulmus pumila* trees in this community. DBH ranges of *Ulmus pumila* in the disturbed types shows from 10 to 30 cm. The shape of tree with wide DBH shows the bending type caused by floods. Large numbers of sprouts begin to grow from the lower part of the trees. The community is mainly composed of species such as *Melilotus suaveolens, Phragmites japonica, Oenothera odorata, Ambrosia artemisiifolia* var. *elatior, Bromus japonicus, Lepidium apetalum, Artemisia capillaris, Barbarea orthoceras*, etc. (Table 1).

On the other hand, the community of the non-disturbance type

Table 1. Species composition of *Ulmus pumila* community in the study area

Serial number	1	2	3	4	5	6	7
Relevé number	4	5	13	8	38	40	41
Altitude (m)	245	245	240	255	225	195	250
Quadrat size(m^2)	50	100	100	100	225	225	200
Height of tree-1 layer(m)	·	·	·	9	12	13	16
Coverage of tree-1 layer(%)	·	·	·	80	60	75	80
Height of subtree layer(m)	6	7	6	·	9	8	9
Coverage of subtree layer(%)	60	40	40	·	60	50	40
Height of shrub layer(m)	·	2	1.3	2	2	2	2
Coverage of shrub layer(%)	·	20	10	5	20	40	10
Height of herb layer(m)	1	1	1	1	1	0.7	0.8
Coverage of herb layer(%)	20	30	20	65	85	90	70
Number of species	14	23	14	14	30	36	41
Community types :	Disturbance type			Non-disturbance type			
Differential species of community :							
Ulmus pumila	4.4	3.2	3.3	5.4	4.3	4.4	5.4
Companions :							
Oenothera odorata	1.1	1.1	·	·	·	·	·
Melilotus suaveolens	1.2		+	·	·	·	·
Artemisia capillaris	+	1.1		·	·	·	·
Trifolium pratense	+	+		·	·	·	·
Torilis japonica	+	+		·	·	·	·
Geranium sibiricum	+	+		·	·	·	·
Chelidonium majus var. *asiaticum*	·	·	·	2.1	2.2	1.1	2.2
Smilax sieboldii	·	·	·	·	+	+	1.1
Glyceria leptolepis	·	·	·	·	2.2	+	+
Rumex crispus	·	·	·	·	+	+	+
Angelica polymorpha	·	·	·	·	·	2.1	1.2
Morus bombycis	·	·	·	·	·	2.2	1.1
Oplismenus undulatifolius	·	·	·	·	·	3.3	+
Carex neurocarpa	·	·	·	·	+	·	2.2
Artemisia princeps var. *orientalis*	·	+	+	2.1	2.2	+	1.1
Humulus japonicus	+	·	+	1.1	+	·	+
Artemisia montana	+	1.1	2.2	1.1	·	·	·
Metaplexis japonica	·	+	+	·	+	·	+
Chrysanthemum boreale	·	1.2	·	+	+	·	1.1
Hemiptelea davidii	·	+	·	·	4.4	+	+
Barbarea orthoceras	+	+	·	2.1	·	·	·
Hemerocallis fulva	·	+	+	·	·	·	+
Phragmites japonica	+	·	·	·	+	·	+
Erigeron annuus	·	1.1	·	·	·	+	+
Boehmeria spicata	·	+	·	·	·	1.2	·
Vicia amoena	·	+	1.2	·	·	·	·
Pilea mongolica	·	·	·	·	·	1.1	+
Persicaria posumbu var. *laxiflora*	·	·	·	·	1.1	·	+

Acer ginnala	·	·	·	·	·	1.1	+
Stachys riederi var. *japonica*	·	·	·	+	·	·	1.1
Achyranthes japonica	·	·	·	·	·	1.1	+
Clematis apiifolia	·	·	·	·	·	+	1.1
Ambrosia artemisiifolia var. *elatior*	1.1	·	·	+	·	·	·
Equisetum arvense	·	·	·	+	+	·	·
Robinia pseudo-acacia	·	·	·	·	+	·	+
Streptolirion cordifolium	·	·	·	·	+	·	+
Phalaris arundinacea	·	+	·	·	·	·	1.1
Ampelopsis brevipedunculata var. *heterophylla*	·	·	·	·	+	·	+
Salix koreensis	·	·	·	·	+	·	+
Carex lanceolata	·	·	·	·	+	·	+
Hosta clausa	·	·	·	·	·	+	+

Others in series no. : *Bidens bipinnata*(1 – +), *Bromus japonicus*(1 – 1.1), *Lepidium apetalum*(1 – +), *Synurus deltoides*(1 – +), *Campanula punctata*(2 – +), *Euonymus alatus* for. *ciliato-dentatus*(2 – +), *Glycine soja*(2 – +), *Lysimachia clethroides*(2 – +), *Sophora flavescens*(2 – +), *Weigela subsessilis*(2 – 1.2), *Agropyron tsukushiense* var. *transiens*(3 – +), *Calamagrostis epigeios*(3 – +), *Lactuca indica* var. *laciniata*(3 – +), *Lespedeza cuneata*(3 – +), *Poa pratensis*(3 – +), *Viola patrinii*(3 – +), *Dioscorea japonica*(4 – 1.1), *Chenopodium album* var. *centrorubrum*(4 – +), *Dactylis glomerata*(4 – +), *Lilium leichtinii* var. *tigrinum*(4 – +), *Aster pekinensis*(5 – +), *Cardamine leucantha*(5 – 1.1), *Cornus walteri*(5 – +), *Corydalis ochotensis*(5 – 2.2), *Galium kinuta*(5 – +), *Isodon inflexus*(5 – +), *Phryma leptostachya* var. *asiatica*(5 – +), *Polygonatum stenophyllum*(5 – +), *Rubus parvifolius*(5 – +), *Stellaria aquatica*(5 – +), *Thalictrum rochebrunianum*(5 – +), *Alangium platanifolium* var. *macrophylum*(6 – +), *Angelica decursiva*(6 – +), *Bidens frondosa*(6 – +), *Celtis aurantiaca*(6 – +), *Corydalis speciosa*(6 – +), *Elsholtzia ciliata*(6 – 1.1), *Galium trachyspermum*(6 – +), *Geum japonicu*(6 – +), *Juglans mandshurica*(6 – +), *Parthenocissus tricuspidata*(6 – +), *Persicaria filiforme*(6 – +), *Persicaria senticosa*(6 – +), *Philadelphus schrenckii*(6 – 1.2), *Potentilla fragarioides* var. *major*(6 – +), *Rubus oldhamii*(6 – +), *Securinega suffruticosa*(6 – +), *Staphylea bumalda*(6 – 1.2), *Uritica angustifolia*(6 – +), *Urtica thunbergiana*(6 – 2.2), *Aster yomena*(7 – +), *Celastrus flagellaris*(7 – +), *Geranium nepalense* subsp. *thunbergii*(7 – +), *Lonicera japonica*(7 – +), *Picrasma quassioides*(7 – +), *Plantago asiatica*(7 – +), *Prunus leveilleana* var. *pendula*(7 – 2.2), *Pyrus ussuriensis*(7 – +), *Rosa multiflora*(7 – +), *Sedum sarmentosum*(7 – +), *Viola acuminata*(7 – +)

forms tree-1 layers of 9～16 m height, with coverage of 60～80%. The non-disturbance type's strata structure is well developed into four layers. Likewise, the non-disturbance type is not greatly influenced by floods because the community is distributed along the riverside. The mean DBH of *Ulmus pumila* is 10~20 cm in the non-disturbance type. The DBH of the individual large trees is 30~55 cm. Most non-disturbance type trees grow vertically. Therefore, there is almost no individual sprouting. The height of the shrub layer in this community is 1.3~2.0 m, with coverage of 5~40%. The height of the herb layer is 0.7~1.0 m, while the coverage is 20~90%.

The non-disturbance type of *Ulmus pumila* community includes more plant species than that of the disturbance type. *Ulmus pumila, Juglans mandshurica, Morus bombycis* in tree-1 layer, *Morus bombycis, Acer ginnala, Celtis aurantiaca, Parthenocissus tricuspidata* in sub-tree layer, *Staphylea bumalda, Philadelphus schrenckii, Alangium platanifolium* var. *macrophylum, Juglans mandshurica, Securinega suffruticosa* in a shrub layer and *Oplismenus undulatifolius, Urtica thunbergiana, Angelica polymorpha, Boehmeria spicata, Achyranthes japonica, Pilea mongolica, Chelidonium majus* var. *siaticum, Elsholtzia ciliata, Smilax sieboldii, Corydalis speciosa*

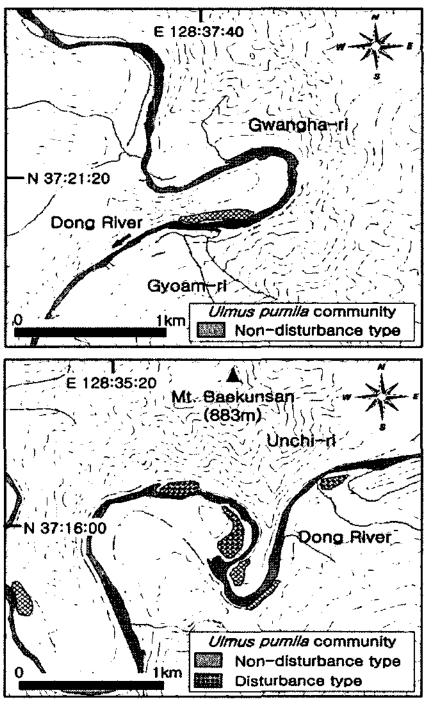

Fig. 2. Distribution maps of *Ulmus pumila* communities along the Dong River area.

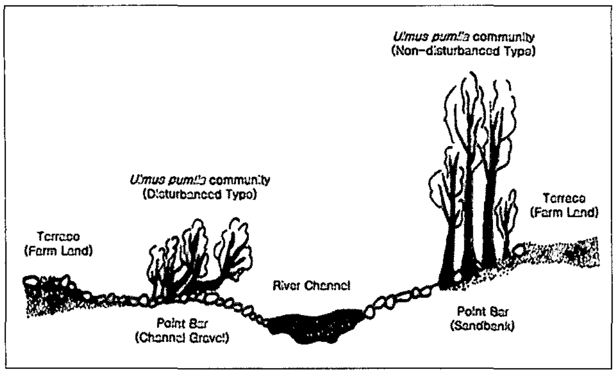

Fig. 3. Vegetation profile of the Ulmus pumila community.

and *Hosta clausa* in herb layer make up the non-disturbance type's *Ulmus pumila* community. *Polygonatum stenophyllum* is a rare species that grow on the sand bank along the riverside.

Such differences in species composition were shown clearly between the disturbance and non-disturbance types by DCA analysis (Fig. 4). In this figure, the two types are obvious at axis 1, 2 and 1,3 respectively.

DISCUSSION

The riparian forest is influenced by flooding. It is a forest vegetation corresponding to a serious change in the environment (Okuda 2001). The *Ulmus pumila* community (bush forests of Siberian elms) is a representative community that forms such riparian forests, although distribution is rare in South Korea. *Ulmus pumila* is sufficiently distributed to form a community along the Dong River. No *Ulmus pumila* community has been reported domestically so far. Therefore, this community is considered to be the largest one in spatial scale.

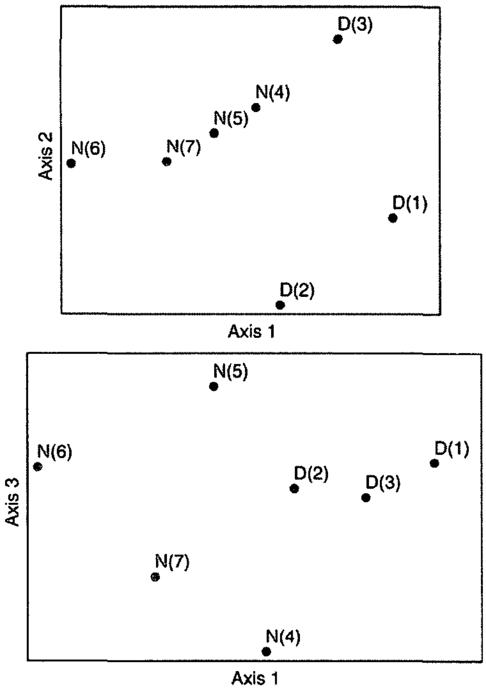

Fig. 4. Stand ordination of the *Ulmus pumila* community.
D: disturbance type, N: non-disturbance type
Parenthesized numbers are relevé number.

The *Ulmus pumila* community grows in gravelly fields and sandy terraces along the Dong River. Generally, *Ulmus pumila* thrives on the foot of rock formations and sandy streamlet terraces (Tsolmon and Kim 2001). The stands developing along the periodically water-bearing streamlets of two meters wide appear like a gallery of forests (Hilbig 1995). These Siberian elm groves including the Spiraea aquilegifoliae-Ulmetum pumilae Hilbig 1987 and Stipo sibiricae-Ulmetum pumilae Mirkin, *et al.* 1986 were identified as relic associations Tsolmon and Kim, 2001. Although the *Ulmus pumila* community in South Korea is developing at a small spatial scale, it is distributed in rivers that are about 50~100 m in width rather than in streamlets. This proves that the species prefers the edges of the stream. We divided the types of *Ulmus pumila* community into two in this study: the disturbance type that appears as a result of flooding, and the non-disturbance type that is less dependent on the occurrence of floods. The disturbance type is about 5~7 m in vegetation height, with the age of the trees greater. As riverbeds change, the trees disappear. New individual trees sprout after flooding(Fig. 5). The non-disturbance type is progressing homogeneously than the disturbance type because the community is formed along the riverside that is not greatly affected by floods. The DCA analysis results suggest that species composition and location of the disturbance type is different from that of the non-disturbance type, *i.e.*, the disturbance type appears mainly in the point bar (channel gravel) where gravel and stone abound, while the non-disturbance type progresses along the riverside. Such differences in location can influence the species composition of the community.

The riparian zone of a river, stream, or other body of water is the land adjacent to the body of water that is, at least periodically, influenced by flooding (Mitsch and Gosselink 1986). Therefore, riparian ecosystems usually occur as an eco-tone between aquatic and upland ecosystems, although with distinct vegetation and soil characteristics (Johnson and McCormick 1979). Usually, the riparian forest is formed and kept in an unstable state with periodic ecological changes brought by water, heaps of earth and sand, water shortage, etc. and by flooding or overflowing of rivers. Organic matter such as plant debris is lost due to flooding, accumulating back into the community. Its nutritive substance therefore becomes

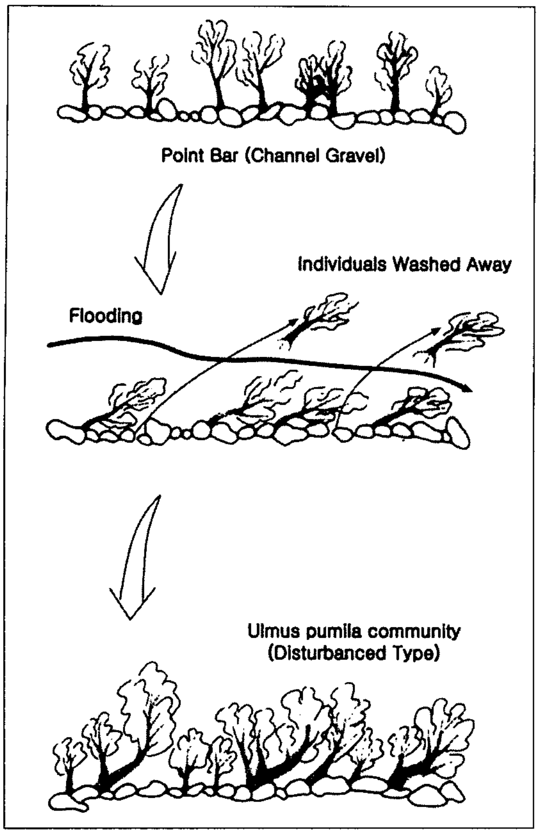

Fig. 5. Dynamics of the disturbance type of trees in the *Ulmus pumila* communities.

a relatively good habitat rising from the surface of the earth (Ohno 1979). In addition, moderate flooding-induced disturbance enhances the richness of the herb species in riparian forests (Decocq 2002). Therefore, the *Ulmus pumila* community represents the characteristics of the riparian forest.

Plant species *Salix koreensis, Salix glandulosa, Alnus japonica, Zelkova serrata*, etc., are known to form riparian forests mainly in South Korea (Song and Song 1996, Lee 1999, Kim 2003). Therefore, the *Ulmus pumila* community in South Korea can regard such high scarcity value as one of the important vegetation landscape for riparian forests. Conservation value of the *Ulmus pumila* community distributed along the Dong River area is evaluated highly because it is formed restrictively only in this area. Based on its flora information, *Ulmus pumila* is considered as a type of northern plant where the Dong River is the south boundary line. Therefore, the species or the community needs continuous attention and conservation countermeasures because there is a limitation in the spread of distribution by natural or manmade factors. Moreover, vegetation information on such riparian forests may be important in restoration (Lee and You 2002). Lack of vegetation information may lead to loss of important natural resources. The rare presence of *Ulmus pumila* was confirmed in the Chungju dam area, Chungcheongbuk-do, South Korea. This suggests that the *Ulmus pumila* community distributed along this area may have disappeared when the dam was constructed. Specially, if there is no conservation countermeasures, the disturbance types may disappear by artificial disturbance such as a dredging.

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