FLORA OF RIPARIAN ZONES AT THE JUNGCHEON RIVER, UIRYEONG-GUN, KOREA

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ABSTRACT

This study of the vegetation of the Jungcheon River in Korea is examined river naturality and vegetative composition of river riparian zones to identify their most important sources of variation. The vegetation of low water's edge was natural weeds, shrubs, and mixed. The vegetation of flood way was both of natural vegetation and artificial vegetation. Land use in riparian zones was urban, residential mixed. Land use in flood plains beyond river levee was park facilities, playground facilities. The composition of the *Pinus densiflora* and *Pinus* ***thunbergii*** was high in the upper regions and the dominant vegetation of low water's edge was *Persicaria longiseta*. At total area, the application of the Braun-Blanquet approach for plant classification in this area is presented in the article. According to the existing phytosociological data, 25 families, 68 genera, 79 species, 10 varieties have been identified. The values of cover-abundance at upper, middle and low regions were 14.87, 11.95, and 10.99, respectively. The loss of natural disturbances in riparian ecosystems due to industrialized land uses must be regarded as one of the main reasons for the decline and extinction of typical floodplain species as well as the loss of biodiversity in this ecosystem. Thus, monitoring for biological diversity of plant species of this river is necessary for an adaptive management approach and the successful implementation of ecosystem management.

Keywords: Braun-Blanquet, Cover-abundance, Jungcheon River, riparian vegetation, river naturality.

INTRODUCTION

A riparian has been defined as the area between the stream channel or near shore portion of a lake or pond and the furthest upland extent of the aquatic system's influence (Gregory et al., 1996). A riparian area is the area of land and water forming a transition from aquatic to terrestrial ecosystems along streams, lakes and open water wetlands. They support high soil moisture and a diversity of associated vegetation and wildlife, and they perform important ecological functions that link aquatic and terrestrial ecosystems. Natural disturbances are caused in floodplains and riparian regions by river dynamics, that means the hydrodynamics (change of inundation and desiccation) and morphodynamics (erosion and accumulation of bedload). Riparian areas are among the most important and diverse parts of forest ecosystems. They support high soil moisture and a diversity of associated vegetation and wildlife, and they perform important ecological functions that link aquatic and terrestrial ecosystems. The strongest physical disturbance for floodplain vegetation is caused by morphodynarnics. One large Reservoir and several beams were installed on the river for agricultural water in this river. In addition, in order to accelerate the flow of water during the flood, there was carried out the rectification. Riparian vegetation plays a very important role in retaining nutrients, sediment and organic matter. Intact riparian vegetation also acts as a very effective filter to maintain or improve water quality. However, at this time, many plants at riparian areas in Korea have been destroyed by new land-use such as road construction or open-air playgrounds and new plants are invading and growing. Riparian vegetation at a particular location and time results from interactions between the physical conditions created by geomorphic and hydrologic processes in the stream channel and responses by the plants.

The Jungcheon River is started at the mountains. The most floodplains of the river have been converted to agricultural or horticultural fields, housing, restricting the river bed to a small channel. Management of riparian areas should give first priority to protecting those areas in natural or nearly natural condition from future alterations. The restoration of altered or degraded areas could then be prioritized in terms of their relative potential value for providing environmental services and/or the cost effectiveness and likelihood that restoration efforts would succeed. Thus, the purpose of this study is to investigate the flora on the Jungcheon River at three regions. Therefore, this survey gathered from this study provides an increasing understanding of the floristic analysis of Jungcheon River riparian areas, which can be used to guide management and improvement of the riverine environment in the river.

METHODOLOGY

Surveyed Regions

This study was carried out on the Jungcheon River (the starting point of upper region: 35°296′851″N/128°234′679″E, the terminal of low region: 35°297′285″N/128°259′047″E), located at Uiryeong-gun, Gyeongsangnam-do province in Korea (Fig. 1). The river is located to the eastern region of the city of Uiryeong-gun. The river is approximately 3.08 kilometers in length with a varying width of between 2.5 and 30.5 meters. Lowlands are usually no higher than 100 m (328 ft.), while uplands are somewhere around 130 m (427 ft.) to 160 m (525 ft.). The upper area of the Jungcheon River, including one reservoir per region, used to be covered with pine trees and other species. The relatively level land can be developed either as agricultural fields or sites for habitation or business (Table 1). Flood plains of this river are usually very fertile agricultural areas and out sides of this river consist of a mosaic of agricultural fields and farming houses. Mean annual temperature ranges from -0.5 (January) to 25.4 °C (August) with 13.0°C, and mean annual precipitation ranges from 15.2 (December) to 294.5 mm (August) with 1275.6 mm.

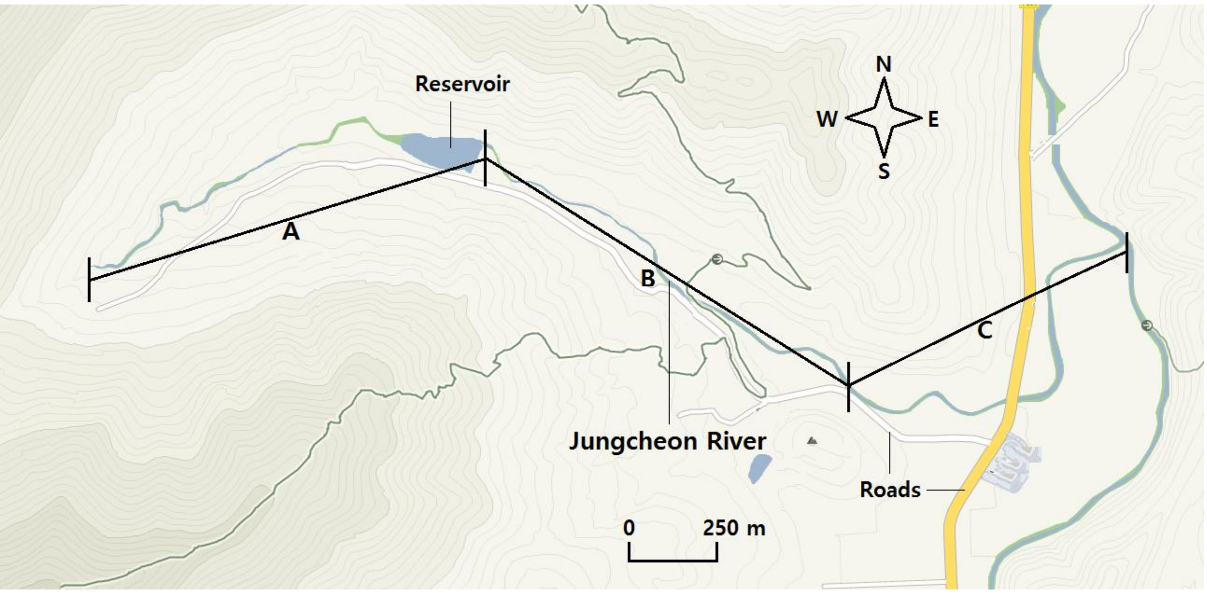

Figure 1: Location of the study area and the three detailed internodes at the Jungcheon River.

Table 1. Land use in flood plains beyond river levee on the Jungcheon River

Region	Length (km)	Mean width (m)	Land use
A	1.54	1.7	Forest area, residence, reservoir, horticulture without N and P fertilizers
B	1.85	3.1	Forest area, residence, cropping with or without N and P fertilizers
C	1.42	4.5	Residence, cropping with N and P fertilizers

Floristic analysis

The field data collection was performed from January to December 2016. Sampling with quadrats (plots of a standard size) can be used for most plant communities (Cox, 1990). Three sectors of the riparian vegetation on the Jungcheon River were chosen to study. The following floristic parameters were recorded within each of the quadrats: all plant taxa, identifiable at the time of sampling, rooted in the stand, a growth form (tree, shrub, grass and forb) was assigned to each species recorded following Westfall (1992). A quadrat delimits an area in which vegetation cover can be estimated, plants counted, or species listed. Quadrats were established randomly, regularly, or subjectively within a study site since plants often grow in clumps, long, narrow plots often include more species than square or round plots of equal area (Moon and Huh, 2016). Each species was collected, mounted, labeled, and systematically arranged in a herbarium. The system of plant classification system was followed by Lee (2007). The identifications of naturalized plants were followed by Korea National Arboretum (2012). Abundance and cover degree are usually estimated together in a single combined estimation or cover-abundance scale from Braun-Blanquet (1964). Two scales are used. One consists of a plus sign and a series of numbers from 1 to 5 denoting both the numbers of species and the proportion of the area covered by that species, ranging from + (sparse and covering a small area) to 5 (covering more than 75% of the area). The second scale indicates how the species are grouped and ranges from Soc. 1 (growing singly) to Soc. 5 (growing in pure populations). In order to relate the model to the field situation in which usually Braun-Blanquet figures are recorded, the % occupancy figures were transformed in to the ordinal transform scale from 1 (one or few individuals) to 9 (75~100% cover of total plot area, irrespective of number of individuals) (Dietvorst et al., 1982). The relative net contribution degree (r-NCD) was obtained by summing up the NCD values for those species belonging to particular taxa under consideration (Kim, 1996).

Biotic Indices

Shannon–Weaver index of diversity (Shannon and Weaver, 1963): the formula for calculating the Shannon diversity index (H') is: $H' = -\Sigma\, p_i \ln p_i$

p_i is the proportion of important value of the ith species ($p_i = n_i/N$, n_i is the important value index of ith species and N is the important value index of all the species), $N = e^{H'}$

The species richness of animals was calculated by using the method, Margalef's index (R) of richness (Magurran, 1988): $R = (S-1)/\ln(n)$

S is the total number of species in a community and n is the total number of individuals observed. Evenness index was calculated using important value index of species (Hill, 1973; Pielou, 1966), $E = H'/\ln(S)$

RESULTS

Upper Region (A): The mean river width at this region is about 1.7 m. The riparian areas of both the river banks are dominated by mixed sediment and the vegetation is composed of herbs, shrub, trees, climbers and macrophytes. Riparian vegetation provides habitat for many wildlife species. At total area, the application of the Braun-Blanquet approach for plant classification in this area is presented in the article. According to the existing phytosociological data, 25 families, 68 genera, 79 species, 10 varieties have been identified (Table 2). Transition zones of this section were distributed pine vegetation. The river width was relative large and the depth of water was swallow and distributions of aquatic plants developed very well in riparian.

The dominant species (according to cover and frequency) that occur in the A region are *Pinus densiflora* and *Pinus* ***thunbergii***. The dominant vegetation of low water's edge was *Persicaria longiseta.* Dominant species in flood plains was *Zoysia japonica.* The survey region was a total of 47 taxa, including 16 families, 41 genera, 43 species, and four varieties. Naturalized plants were ten species. The total transformed Braun-Blanquet value and r-NCD at upper area were 115 and 1,437.5, respectively.

The value of cover-abundance was total 14.87 (Table 3). Cover-abundance values of trees and shrubs were 7.50 and 2.40, respectively. Cover-abundance values of grasses and forbs were 2.53 and 2.44, respectively. A Shannon-Weaver indices (H´) of diversity were varied from 0.69 (trees) to 3.10 (forbs). For the community as a whole, richness of trees was very low (0.37). The total richness indices were varied from 0.37 (trees) to 5.84 (forbs). The evenness indices were varied from 0.96 (forbs) to 1.00 (trees). Although evenness indices were different from each other, there were not shown significant differences ($p < 0.05$).

Middle Region (B)

The mean river width at the region is about 3.1 m. The vegetation of low water's edge was natural weeds, shrubs, and mixed. The dominant species of left and right riparian areas was Gramineae vegetation (*Zoysia japonica*) (Table 2). The dominant vegetation of low water's edge was *Persicaria longiseta.* Land use in flood plains beyond river levee was dominated *Pinus densiflora* and *Pinus* ***thunbergii***. Other phyla were occasionally recorded in low densities. The survey region was a total of 68 taxa, including 19 families, 53 genera, 60 species, and eight varieties. Naturalized plants were 17 species.

The total transformed Braun-Blanquet value and r-NCD at middle area were 165 and 2,063.5, respectively. The value of cover-abundance was total 11.95 (Table 4). A Shannon-Weaver indices (H´) of diversity were varied from 1.26 (trees) to 3.65 (forbs). The total richness indices were varied from 1.02 (trees) to 3.96 (forbs). The evenness indices were varied from 0.86 (shrubs) 0.98 (forbs). Although evenness indices were different from each other, there were not shown significant differences ($p < 0.05$).

Low Region (C)

The mean river width at the region was about 4.5 m. The vegetation of low water's edge was blocked by stonework etc. Riverbed area was dominated by the distribution of the willow (*Salix gracilistyla*). The survey region was a total of 72 taxa, including 21 families, 53 genera, 64 species, and eight varieties (Table 2). Naturalized plants were 21 species. The total transformed Braun-Blanquet value and r-NCD at middle area were 197 and 2,462.5, respectively. The value of cover-abundance was total 10.99 (Table 3). A Shannon-Weaver index (H´) of diversity was different across growth forms, varying from 1.37 (trees) to 3.62 (forbs). The total richness indices were varied from 1.25 (trees) to 4.47 (forbs). The evenness indices were varied from 0.96 (shrubs) 0.99 (trees).

Table 2: List of vascular plants, Braun-Blanquet's score, and r-NCD at three regions of the Jungcheon River

Family	Species	Region			Invaded plant	r-NCD		
		A	B	C		A	B	C
Equisetaceae	*Equisetum arvense* L.	4	5	5		50.0	62.5	62.5
Pinaceae	*Pinus densiflora* S. et Z.	8	8	2		100.0	100.0	25.0
	Pinus ***thunbergii*** Parl.	7	6	3		87.5	75.0	37.5
Salicaceae	*Populus euramericana* Guinier		2	3			25.0	37.5
	Salix gracilistyla Miq.		2	3			25.0	37.5
	Salix koriyanagi Kimura			4				50.0
Moraceae	*Morus alba* L.	2	2			25.0	25.0	
Cannabinaceae	*Humulus japonicus* S. et Z.	4	3	2		50.0	37.5	25.0
Urticaceae	*Boehmeria longispica* Steud.	5	4	2		62.5	50.0	25.0
	Boehmeria spicata (Thunb.) Thunb.	5	3	1		62.5	37.5	12.5
Polygonaceae	*Persicaria hydropoper* (L.) Spach.	2	4	5		25.0	50.0	62.5
	Persicaria longiseta (De Bruyn) Kitagawa	6	7	7		75.0	87.5	87.5
	Persicaria nodosa (Persoon) Opiz	2	3			25.0	37.5	
	Persicaria orientalis Spach		2	2			25.0	25.0
	Persicaria thunbergii H. Gross		2	4			25.0	50.0
	Rumex acetocella L.	2	3	5	NAT	25.0	37.5	62.5
	Rumex acetosa L.		2	4			25.0	50.0
	Rumex conglomeratus Murr.			3	NAT			37.5
	Rumex crispus L.			3	NAT			37.5
	Rumex nipponicus Fr. et Sav.		2	3			25.0	37.5
Chenopodiaceae	*Chenopodium acuminatum* Willd.		2	3			25.0	37.5
	Chenopodium album L.		1	2	NAT		12.5	25.0
	Chenopodium album var. *centrorubrum* Makino		2	3			25.0	37.5

Amaranthaceae	*Achyranthes japonica* (Miq.) Pa.	1		2		12.5		25.0
	Amaranthus lividus L.			4	NAT			50.0
Phytolaccaceae	*Phytolacca americana* L.	2			NAT	25.0		
Brassicaceae	*Brassica juncea* Czern		2	3			25.0	37.5
	Brassica vampestris var. *nippo-oleifera* Makino		2	4			25.0	50.0
	Capsella bursa-pastoris (L.) Medicus	2	2	3		25.0	25.0	37.5
	Lepidium apetalum Willd.			3	NAT			37.5
	Lepidium virginicum L.			2	NAT			25.0
	Thlaspi arvense L.		1	3	NAT		12.5	37.5
Caryophyllaceae	*Arenaria serpyllifolia* L.		2	2			25.0	25.0
	Stellaria aquatica (L.) Scop.		2	3			25.0	37.5
Rosaceae	*Duchesnea chrysantha* (Zoll. Et Morr) Miq.	2	2			25.0	25.0	
	Potentilla fragarioides var. *major* Max.	3	2			37.5	25.0	
	Prunus serrulata var. *spontanea* (Max.) Wils.		3	3			37.5	37.5
	Rosa multiflora Thunb.	2	2			25.0	25.0	
Leguminosae	*Amorpha fruticosa* L.	2	2	2	NAT	25.0	25.0	25.0
	Astragalus sinicus L.	2	5	4	NAT	25.0	62.5	50.0
	Kummerowia striata (Thunb.) Schindl.	1	1			12.5	12.5	
	Pueraria lobata (Willd.) Ohwi			1				12.5
	Trifolium pratense L.	2	2	3	NAT	25.0	25.0	37.5
	Trifolium repens L.		2	2	NAT		25.0	25.0
	Vicia tetrasperma (L.) Moench	2	2		NAT	25.0	25.0	
Oxalidaceae	*Oxalis corniculata* L.		2	2			25.0	25.0
	Oxalis stricta L.		2				25.0	
Violaceae	*Viola patrinii* DC.	2	2			25.0	25.0	
Onagraceae	*Oenothera odorata* Jacq.			2	NAT			25.0

Umbelliferae	*Oenanthe javanica* (Bl.) DC.	2		5		25.0		62.5
Oleaceae	*Forsythia koreana* Nakai		2	3			25.0	37.5
Plantaginaceae	*Plantago asiatica* L.	3	2	2		37.5	25.0	25.0
	Plantago laceolata L.	2	2	2	NAT	25.0	25.0	25.0
Caprifoliaceae	*Lonicera japonica* Thunb.			1				12.5
Compositae	*Ambrosia artemisiifolia* var. *elatior* Descourtils		1		NAT		12.5	
	Artemisia princeps Pampan.	2	3			25.0	37.5	
	Aster ciliosus Kitamura		3	2			37.5	25.0
	Bidens bipinnata L.	2	2	2		25.0	25.0	25.0
	Bidens frondosa L.			1	NAT			12.5
	Cirsium japonicum var. *ussuriense* Kitamura			4				50.0
	Cosmos bipinnatus Cav.	2	2	4	NAT	25.0	25.0	50.0
	Conyza canadensis L.	1	2	3	NAT	12.5	25.0	37.5
	Erechtites hieracifolia Raf.	2			NAT	25.0		
	Erigeron annuas (L.) Pers.		2		NAT		25.0	
	Galingosa ciliate Blake		2	3	NAT		25.0	37.5
	Petasites japonicus (Sieb. et Zucc.) Maxim.	2	2			25.0	25.0	
	Tagetes minuta L.		1	4			12.5	50.0
	Taraxacum officinale Weber	1	2	3	NAT	12.5	25.0	37.5
	Xanthium strumarium L.		3	3	NAT		37.5	37.5
Gramineae	*Agropyron tsukusinense* (Honda) Ohwi	3	4	2		37.5	37.5	25.0
	Alopecurus aequalis var. *amurensis* Ohwi.	2	3	3		25.0	37.5	37.5
	Alopecurus pratensis L.	2	2	2		25.0	25.0	25.0
	Avena fatua L.	2	2	3	NAT	25.0	25.0	37.5
	Argostis clavata var. *nukabo* Ohwi.	2	1	2		25.0	12.5	25.0
	Beckmannia syzigachne (Steud.) Fern.	3	1	2		37.5	12.5	25.0

	Bromus japonicus Thunb.	2	2	3		25.0	25.0	37.5
	Cymbopogon tortilis var. *goeringii* Hand-Mazz.	2		2		25.0		25.0
	Digitaria sanguinalis (L.) Scop.	2		2		25.0		25.0
	Echinochloa crus-galli (L.) Beauv.	2	1	3		25.0	12.5	37.5
	Miscanthus sacchariflorus Benth.		2	3			25.0	37.5
	Miscanthus sinensis var. *purpurascens* Rendle		2	3			25.0	37.5
	Phalaris arundinacea L.			2				25.0
	Phragmites japonica Steud.	1	2	2		12.5	25.0	25.0
	Poa sphondylodes Trin.		2				25.0	
	Setaria viridis (L.) Beauv.	3	4	4		37.5	50.0	50.0
	Zoysia japonica Steud.	6	8	7		75.0	100.0	87.5
Cyperaceae	*Carex dimorpholepis* Steud.			3				37.5
	Carex neurocarpa Maxim.	2		3		25.0		37.5
Commelinaceae	*Commelina communis* L.		3				37.5	
Total		115	165	197		1437.5	2063.5	2462.5

NAT: Naturalized plants.

Table 3. Mean cover-abundance of species and diversity indices at the Jungcheon River

Growth form	No. species (%)	Mean cover-abundance of species	Diversity (H`)	Diversity (N)	Richness	Evenness
A region						
Trees	2 (4.3)	7.50	0.69	1.99	0.37	1.00
Shrubs	5 (10.6)	2.40	1.56	4.76	1.61	0.97
Grasses	15 (31.9)	2.53	2.62	13.74	3.85	0.97
Forbs	25 (63.9)	2.44	3.10	22.19	5.84	0.96
Total	47 (100.0)	14.87	-	-	-	-
B region						
Trees	4 (5.8)	4.75	1.26	3.51	1.02	0.91
Shrubs	7 (10.1)	2.14	1.67	5.29	2.22	0.86
Grasses	16 (23.2)	2.75	2.60	13.47	3.96	0.94
Forbs	42 (60.9)	2.31	3.65	38.37	8.96	0.98
Total	69 (100)	11.95	-	-	-	-
C region						
Trees	4 (5.6)	2.75	1.37	3.95	1.25	0.99
Shrubs	9 (12.5)	2.22	2.11	8.26	2.67	0.96
Grasses	19 (26.4)	2.9	2.87	17.65	4.47	0.98
Forbs	40 (55.6)	3.08	3.62	37.29	8.10	0.98
Total	72 (100)	10.99	-	-	-	-

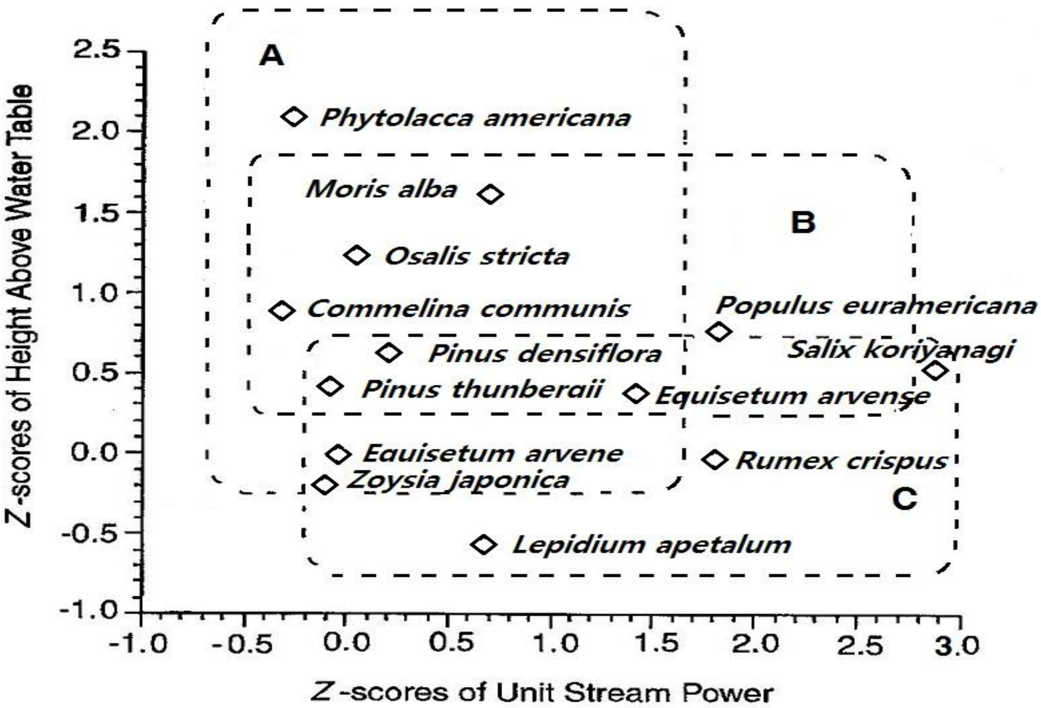

Figure 2. Relationship of 13 common Busan riparian species to unit stream power and height above water table. A, B, and C are regions of Jungcheon River. Modified from Benix and Hupp (2000).

DISCUSSION

The spatial heterogeneity of environmental resources results in the variance seen in the spatial distribution of vegetation (Fig. 2). The upstream of the Jungcheon River is fast and the downstream of the river is slow. In addition, surfaces of most river are usually fast and the speed of water is slow at the bottom of the river. Common species were sorted along a power, but those species that occurred on surface with low/stream power were differentiated along a gradient of height above water table. The species found in locales with high stream power are either quite flexible, such as genus *Pinus* or grow so large that mature individuals are resistance to flood damage, such as *Populus* (Benix and Hupp, 2000).

Vegetated riparian areas are efficient and cost-effective tools for pollution control. Many contaminants from urban and rural areas bind to sediments that, when washed into waterways, constitute large masses of pollutant loadings. These contaminants include most forms of nitrogen and phosphorus, hydrocarbons, PCBs, most metals, and pesticides. Natural disturbances play a central role for the survival of typical riparian plants and the reservation of the typical riparian vegetation as the examples have shown. But also for the preservation of typical wildlife in flood plains the importance of natural disturbances is proven (Plachter, 1996; Reich, 1991). The importance of floodplains as corridors in the landscape is changing by the alteration of the disturbance regime (Miiller, 1995). Under natural disturbances floodplains are important for the diffusion of native plant species and the connection of habitats. Under human disturbances the invasion of alien plants is supported, due to the changing habitat conditions - riparian landscapes function as corridors for the diffusion of aliens in the landscape (Miiller, 1995). From 25 most frequent invaders in the natural vegetation were found in the Jungcheon River (Table 2). The loss of natural disturbances in riparian ecosystems due to industrialized land uses must be regarded as one of the main reasons for the decline and extinction of typical floodplain species as well as the loss of biodiversity in this ecosystem (Kattelmann & Embur, 1996). There are a variety of threats to the natural integrity of riparian areas because they are valuable in economic as well as ecological terms. Reservoirs, roads, and urban areas break up the continuity of riparian corridors, one of their critical ecological attributes. The Jungcheon River is also undergoing such changes due to industrialization. A conservation strategy for the riparian vegetation of this river is needed before much destruction has taken place.

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