FLORA OF AQUATIC AND RIPARIAN ZONES AT THE SHINJEON RIVER IN HAPCHEON-GUN, KOREA

Man-Kyu, Huh
Dong-eui University
SOUTH KOREA
mkhuh@deu.ac.kr

ABSTRACT

Riparian zones are an interface between terrestrial and aquatic ecosystems and also play a critical role in supporting biota and biodiversity. This study was examined vegetative composition of river riparian zones at the Shinjeon River in Korea. Transition zones of the upper region were distributed pine and Quercus vegetation. The vegetation of low water's edge at upper region were naturally formed various vegetation communities by *Equisetum arvense*, *Taraxacum officinale,* and *Miscanthus sinensis* var. *purpurascens.* The total transformed Braun-Blanquet value and r-NCD at upper region were 149 and 2,128.6, respectively. Cover-abundance values of trees and shrubs were 3.83 and 2.88, respectively. Cover-abundance values of grasses and forbs were 3.33 and 2.54, respectively. A Shannon-Weaver indices (H´) of diversity were varied from 1.38 (trees) to 5.45 (forbs). The dominant species of left and right riparian areas at middle region were Polygonaceae (eight species), Brassicaceae (seven species), Compositae (nine species including *Taraxacum officinale*), and Gramineae vegetation (18 species including *Miscanthus sinensis* var. *purpurascens* and *Zoysia japonica*). The low region was a total of 73 taxa, including 16 families, 57 genera, 62 species, one subspecies, and nine varieties. Naturalized plants at low region were 24 species. The total transformed Braun-Blanquet value and r-NCD at low area were 249 and 2,766.7, respectively.

Keywords: Braun-Blanquet, Cover-abundance, Shinjeon River, riparian vegetation.

INTRODUCTION

Riparian areas are invariably defined as being directly adjacent to a waterbody, typically a stream. Definitions vary to the extent that they include all stream types, from perennial to ephemeral. Occupying the space between land and water, these areas are characterized by multiple transitions in soil, biota, and hydrology. Some scientists have described riparian areas as "ecotones" or interfaces between terrestrial and aquatic ecosystems (Gregory, 1997), while others have embraced riparian ecosystems as landscape units comprising an array of zones that extend from aquatic to upland environments (Brinson, 1990). In either case, riparian areas clearly are characterized by gradients in environmental conditions, ecological processes, and species that make it difficult to assign them discrete boundaries (Naiman et al., 1993). Riparian zones are an interface between terrestrial and aquatic ecosystems and also play a critical role in supporting biota and biodiversity. Vegetation found in riparian zones usually includes hydrophytes and species which also occur in drier sites. The natural succession of vegetative types following major disturbances such as floods, fires or logging, determines the kinds of vegetation occurring in a riparian zone at any given time. Pioneer species include willows on gravel bars and red alder on mineral soil (Campbell and Franklin 1979).

Riparian lands usually support significant plant communities that are generally denser, faster growing and have a greater number of layers or strata, than adjacent plant communities. They also perform a variety of valuable functions. Through the interaction of their soils, hydrology, and biotic communities, riparian forests protect and improve water quality, provide habitat for plants and animals, support aquatic communities, and provide many benefits to humans. In addition, riparian vegetation provides habitat for many wildlife species.

In many regions, riparian areas constitute a small proportion of total watershed area. At local scales, riparian areas act as ecotones between aquatic and terrestrial ecosystems, while at landscape and watershed scales, riparian areas function as both boundaries and corridors between terrestrial and aquatic ecosystems (Goebel et al., 2007).

Knowledge of the status of riparian lands in Korea, both in quantity and quality, is fundamental to any management program that sets goals for improvement. This information should include whether the resource is increasing or decreasing over time, the geographic distribution of these changes, and, ideally, data on the condition of existing riparian areas. The Shinjeon River is started at the mountains. 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. The purpose of this study is to investigate the flora on the Shinjeon River at three regions. This survey gathered from this study provides an increasing understanding of the floristic analysis of Shinjeon 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 Shinjeon River (the starting point of upper region: 35°381′217″N/128°189′579″E, the terminal of low region: 35°409′344″N/128°122′393″E), located at Hapcheon-gun, Gyeongsangnam-do Province in Korea (Fig. 1). The river is approximately 3.66 kilometers in length with a varying width of between 3.07 and 8.65 meters. Lowlands are usually no higher than 120 m (394 ft.), while uplands are somewhere around 430 m (1411 ft.) to 450 m (1476 ft.). The upper area of the Shinjeon River, including one big reservoir and two small reservoirs, used to be covered with pine or Quercus trees and other species. The relatively level land can be developed either as agricultural fields or sites for habitation or business (Table 1). 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.

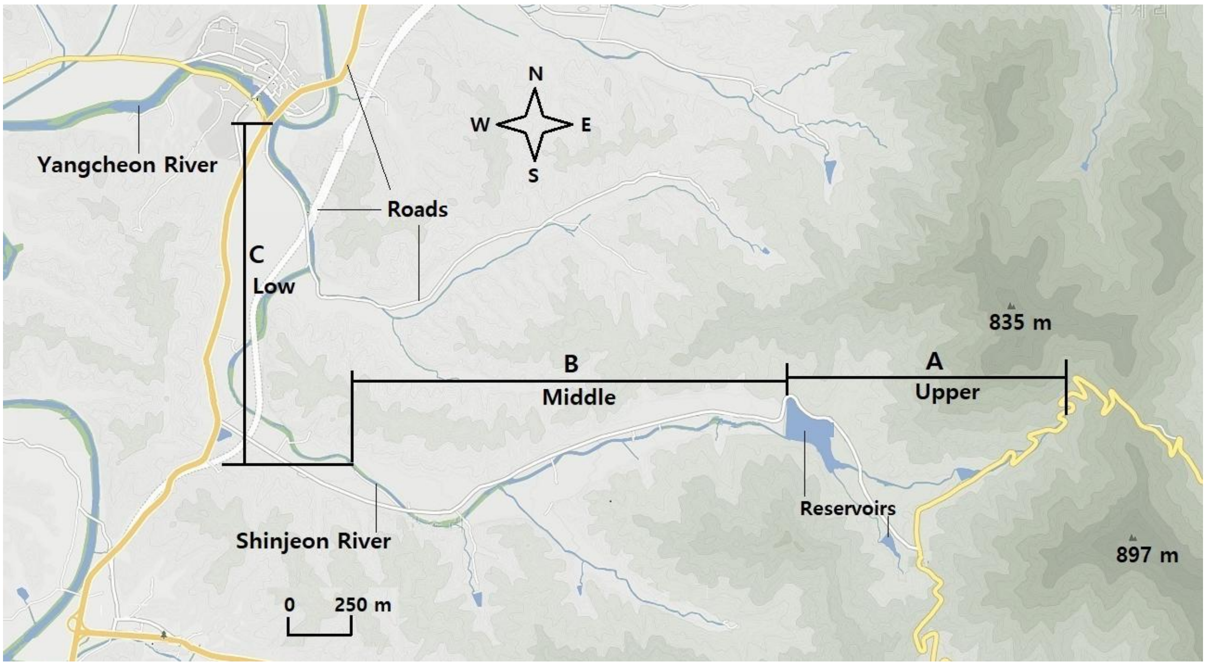

Figure 1: Location of the study area and the three detailed internodes at the Shinjeon River.

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

Region	Length (km)	Mean width (m)	Land use
A	1.25	3.07	Forest area, reservoir, horticulture without N and P fertilizers
B	1.35	5.81	Forest area, residence, farmland (cropping with N and P fertilizers)
C	1.58	8.65	Roads, residence, farmland (cropping with N and P fertilizers)

Floristic analysis

The field data collection was performed from January to December 2017. Sampling with quadrats (plots of a standard size) can be used for most plant communities (Cox, 1990). Along the transect lines of each study site, 10 m × 10 m quadrats were laid down at every 10 m altitudinal drop to analyze species turnover. Each transect contains different numbers of plots depending on the length of each transect. In addition, five 1 m × 1 m subplots, one at each of the four corners and one at the center of the 10 m × 10 m main plot were also laid to sample herbaceous plants. Three sectors of the riparian vegetation on the Shinjeon River were chosen to study. Three internodes (regions) were selected along the course of the Shinjeon River.

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. 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). Relationship of riparian species to unit stream power and height were calculated by Benix and Hupp (2000).

Biotic Indices

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

*p*i is the proportion of important value of the *i*th species (*p*i = *n*i/N, *n*i is the important value index of *i*th species and N is the important value index of all the species), $N2 = 1/\lambda$.

Where λ (Simpson's index) for a sample is defined as $\lambda = \sum\{ ni(ni-1)/ N(N-1)\}$

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 results from this study showed that plant species of different life forms (trees, shrubs, lianas and herbs) were identified from the vegetation of the Shinjeon River. The mean river width at this region is about 3.1 m (Table 1). The riparian areas of both river banks are dominated by mixed vegetation and the various vegetation are composed of herbs, shrub, trees, climbers and macrophytes. Transition zones of this section were distributed pine and Quercus vegetation. The river width was relative large and the depth of water was swallow and distributions of aquatic plants developed very well in riparian. 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, 19 families, 48 genera, 45 species, one subspecies, 9 varieties have been identified (Table 2). Naturalized plants were three species.

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 thunbergii*. The vegetation of low water's edge were naturally formed various vegetation communities by *Equisetum arvense, Taraxacum officinale,* and *Miscanthus sinensis* var. *purpurascens*. Dominant species in flood plains was *Zoysia japonica*. The total transformed Braun-Blanquet value and r-NCD at upper area were 149 and 2,128.6, respectively.

The value of cover-abundance was total 12.58 (Table 3). Cover-abundance values of trees and shrubs were 3.83 and 2.88, respectively. Cover-abundance values of grasses and forbs were 3.33 and 2.54, respectively. A Shannon-Weaver indices (H´) of diversity were varied from 1.38 (trees) to 5.45 (forbs). For the community as a whole, the mean value of richness was 3.343. The total richness indices were varied from 1.59 (trees) to 5.97 (forbs). The evenness indices were varied from 0.77 (trees) to 1.73 (grasses). Although evenness indices were different from each other except trees, there were not shown significant differences ($p < 0.05$).

Middle Region (B)
The mean river width at the region is about 5.81 m (Table 1). The vegetation of low water's edge was natural weeds, shrubs, and mixed. The dominant species of left and right riparian areas were Polygonaceae (eight species), Brassicaceae (seven species), Compositae (nine species including *Taraxacum officinale*), and Gramineae vegetation (18 species including *Miscanthus sinensis* var. *purpurascens* and *Zoysia japonica*) (Table 2). The dominant vegetation of low water's edge was *Miscanthus sinensis* var. *purpurascens*. Land use in flood plains beyond river levee was dominated crop plants. Other phyla were occasionally recorded in low densities. The survey region was a total of 69 taxa, including 18 families, 55 genera, 59 species, and 10 varieties. Naturalized plants were 16 species.

The total transformed Braun-Blanquet value and r-NCD at middle area were 191 and 2,387.5, respectively. The value of cover-abundance was total 10.47 (Table 4). A Shannon-Weaver indices (H´) of diversity were varied from 0.54 (trees) to 7.01 (forbs). The total richness indices were varied from 1.03 (trees) to 8.08 (forbs). The evenness indices were varied from 4.20 (shrubs) 38.68 (forbs). Their evenness indices were different from each other and there were shown significant differences ($p < 0.01$).

Low Region (C)
The mean river width at the region was about 8.65 m (Table 1). The vegetation of low water's edge was blocked by stonework etc. Land use in riparian zones within river levee was arable land, urban, residential mixed. The survey region was a total of 73 taxa, including 16 families, 57 genera, 62 species, one subspecies, and nine varieties (Table 2). Naturalized plants were 24 species. The total transformed Braun-Blanquet value and r-NCD at low area were 249 and 2,766.7, respectively.

The value of cover-abundance was total 13.35 (Table 3). Cover-abundance values of trees and shrubs were 2.67 and 2.25, respectively. Cover-abundance values of grasses and forbs were 4.89 and 3.54, respectively. A Shannon-Weaver index (H´) of diversity was different across growth forms, varying from 0.16 (trees) to 8.94 (forbs). The total richness indices were varied from 0.96 (trees) to 9.15 (forbs). The evenness indices were varied from 3.50 (trees) to 77.65 (forbs). Their evenness indices were different from each other and there were shown significant differences ($p < 0.01$).

The spatial heterogeneity of environmental resources results in the variance seen in the spatial distribution of vegetation (Fig. 2). The upstream of the Shinjeon River is fast and the downstream of the river is slow.

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

Family	Species	Region			Invaded plant	r-NCD		
		A	B	C		A	B	C
Equisetaceae	*Equisetum arvense* L.	6	5	5		85.7	62.5	55.6
Pinaceae	*Pinus densiflora* S. et Z.	6	3	2		85.7	37.5	22.2
	Pinus ***thunbergii*** Parl.	5	2	2		71.4	25.0	22.2
Salicaceae	*Salix gracilistyla* Miq.		2	2			25.0	22.2
	Salix koriyanagi Kimura		2	2			25.0	22.2
Fegaceae	*Castanea crenata* Sieb. Et Zucc	5				71.4		
	Quercus dentata Thunb. ex Murray	3				42.9		
	Quercus variabilis Blume	2				28.6		
Moraceae	*Morus alba* L.	4				57.1		
Cannabinaceae	*Humulus japonicus* S. et Z.	2	1			28.6	12.5	
Urticaceae	*Boehmeria longispica* Steud.	3	2			42.9	25.0	
	Boehmeria platanifolia Franch. & Sav.	3	1			42.9	12.5	
	Boehmeria spicata (Thunb.) Thunb.	2	1			28.6	12.5	
	Pilea mongolica Wedd.	2				28.6		
Santalaceae	*Thesium chinense* Turcz.	1				14.3	14.3	
Polygonaceae	*Persicaria filifomis* (Thunb.) Nakai et Mori	1	2	4		1403	25.0	44.4
	Persicaria orientalis Spach		2	2			25.0	22.2
	Persicaria thunbergii H. Gross	7	3	4		100.0	37.5	44.4
	Rumex acetocella L.		2	2	NAT		25.0	22.2
	Rumex acetosa L.		2	4			25.0	44.4
	Rumex conglomeratus Murr.		3	5	NAT		37.5	55.6
	Rumex crispus L.	1	2	4	NAT	14.3	25.0	44.4
	Rumex nipponicus Fr. et Sav.		2	4			25.0	44.4

Chenopodiaceae	*Chenopodium acuminatum* Willd.		2	2			25.0	22.2
	Chenopodium album L.		2	4	NAT		25.0	44.4
	Chenopodium album var. *centrorubrum* Makino	2	3	4		28.6	37.5	44.4
Amaranthaceae	*Achyranthes japonica* (Miq.) Pa.	2	2	3		28.6	25.0	33.3
	Amaranthus lividus L.			3	NAT			33.3
Phytolaccaceae	*Phytolacca americana* L.		2	1	NAT		25.0	11.1
Brassicaceae	*Brassica vampestris* var. *nippo-oleifera* Makino		2	5			25.0	55.6
	Capsella bursa-pastoris (L.) Medicus		4	5			50.0	55.6
	Cardamine leucantha O.E. Schulz		2	3			25.0	33.3
	Lepidium apetalum Willd.			4	NAT			44.4
	Lepidium virginicum L.		3	4	NAT		37.5	44.4
	Raphnus sativa L.		2	2			25.0	22.2
	Rorippa indica (L.) Hiern	2	2	4		28.6	25.0	44.4
	Thlaspi arvense L.	1	3	4	NAT	14.3	37.5	44.4
Rosaceae	*Potentilla fragarioides* var. *major* Max.	3	2			42.9	25.0	
	Prunus serrulata var. *spontanea* (Max.) Wils.	2	2	4		28.6	25.0	44.4
	Rosa hybrid Hort.			2				22.2
	Rosa multiflora Thunb.	3	2			42.9	25.0	
	Rubus crataegifolius Bunge			1				11.1
Leguminosae	*Albizzia julibrissin* Durazz.	2	4	3		28.6	50.0	33.3
	Amorpha fruticosa L.	4			NAT	57.1		
	Glycine soja S. et Z.	2	4	4		28.6	50.0	44.4
	Kummerowia striata (Thunb.) Schindl.		2	3			25.0	33.3
	Pueraria lobata (Willd.) Ohwi	4				57.1		
	Robinia pseudo-acacia L.	2			NAT	28.6		
	Trifolium pratense L.			2	NAT			22.2

	Trifolium repens L.		4	5	NAT		50.0	55.6
	Vicia tetrasperma (L.) Moench			2	NAT			22.2
Oxalidaceae	*Oxalis corniculata* L.		2	4			25.0	44.4
	Oxalis stricta L.		2	3			25.0	33.3
Violaceae	*Viola patrinii* DC.	3				42.9		
Onagraceae	*Oenothera odorata* Jacq.			4	NAT			44.4
Umbelliferae	*Oenanthe javanica* (Bl.) DC.		3	3			37.5	33.3
Oleaceae	*Forsythia koreana* Nakai	2	3			28.6	37.5	
Plantaginaceae	*Plantago asiatica* L.	2	5	5		28.6	62.5	55.6
	Plantago laceolata L.			1	NAT			11.1
Geraniaceae	*Geranium nepalense* subsp. *thunbergii* Hara	1		2		14.3		22.2
Euphorbiaceae	*Acalypha australis* L.		2	4			25.0	44.4
Compositae	*Ambrosia artemisiifolia* var. *elatior* Descourtils		1	3	NAT		12.5	33.3
	Artemisia princeps Pampan.	2	8	5		28.6	100.0	55.6
	Aster tataricus L.			2	NAT			22.2
	Bidens bipinnata L.	2	2			28.6	25.0	
	Bidens frondosa L.			4	NAT			44.4
	Cirsium japonicum var. *ussuriense* Kitamura	1	2	3		14.3	25.0	33.3
	Cosmos bipinnatus Cav.			5	NAT			55.6
	Conyza canadensis L.			5	NAT			55.6
	Erechtites hieracifolia Raf.		2	3	NAT		25.0	33.3
	Erigeron annuas (L.) Pers.	2	4	3	NAT	28.6	50.0	33.3
	Galingosa ciliate Blake	4	2		NAT	57.1	25.0	
	Petasites japonicus (Sieb. et Zucc.) Maxim.	2				28.6		
	Tagetes minuta L.			2	NAT			22.2
	Taraxacum mongolicum H. Mazz.	6	7	7		85.7	87.5	77.8

	Taraxacum officinale Weber	7	8	8	NAT	100.0	100.0	88.9
Gramineae	*Agropyron tsukusinense* (Honda) Ohwi	2	4	5		28.6	50.0	55.6
	Alopecurus aequalis var. *amurensis* Ohwi.	2	3	6		28.6	37.5	66.7
	Alopecurus pratensis L.	4	5	7		57.1	62.5	77.8
	Avena fatua L.	2	4	5	NAT	28.6	50.0	55.6
	Artemisia princeps var. *orientalis* (Pampan.) Hara	2	2	3		28.6	25.0	33.3
	Artemisia selengensis Turccz.		3	2			37.5	22.2
	Beckmannia syzigachne (Steud.) Fern.		3	5			37.5	55.6
	Bromus japonicus Thunb.	2	3	3		28.6	37.5	33.3
	Cymbopogon tortilis var. *goeringii* Hand-Mazz.	2	2			28.6	25.0	
	Digitaria sanguinalis (L.) Scop.	4	4	2		57.1	50.0	22.2
	Echinochloa crus-galli (L.) Beauv.			4				44.7
	Miscanthus sacchariflorus Benth.	5	6	6		71.4	75.0	66.7
	Miscanthus sinensis var. *purpurascens* Rendle	6	7	4		85.7	87.5	44.4
	Phalaris arundinacea L.	2	4	5		28.6	50.0	55.6
	Phragmites japonica Steud.		6	5			75.0	55.6
	Poa sphondylodes Trin.	4	5	5		57.1	62.5	55.6
	Setaria viridis (L.) Beauv.	5	6	6		71.4	75.0	66.7
	Xanthium strumarium L.	2	2			28.6	25.0	
	Zoysia japonica Steud.	6	7	9		85.7	87.5	100.0
Total								

NAT: Naturalized plants.

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

Growth form	No. species (%)	Mean cover-abundance of species	Diversity (H`)	Diversity (N)	Richness	Evenness
A region						
Trees	6 (10.9)	3.83	1.38	6.33	1.59	0.77
Shrubs	8 (14.5)	2.88	2.79	9.73	2.23	1.34
Grasses	15 (27.3)	3.33	4.67	16.12	3.58	1.73
Forbs	26 (47.3)	2.54	5.45	35.75	5.97	1.67
Total	55 (100.0)	12.58	-	-	-	-
B region						
Trees	3 (4.3)	2.33	0.54	4.20	1.13	0.49
Shrubs	8 (11.6)	2.00	2.53	10.00	2.00	1.22
Grasses	19 (27.5)	4.32	6.08	20.63	2.09	2.07
Forbs	39 (56.5)	2.82	7.01	38.68	3.72	1.91
Total	69 (100)	10.47	-	-	-	-
C region						
Trees	3 (4.1)	2.67	0.16	3.50	0.96	0.14
Shrubs	4 (5.5)	2.25	1.26	6.00	1.37	0.91
Grasses	18 (24.7)	4.89	6.07	19.43	3.80	2.10
Forbs	48 (65.8)	3.54	8.94	77.65	9.15	2.31
Total	72 (100)	13.35	-	-	-	-

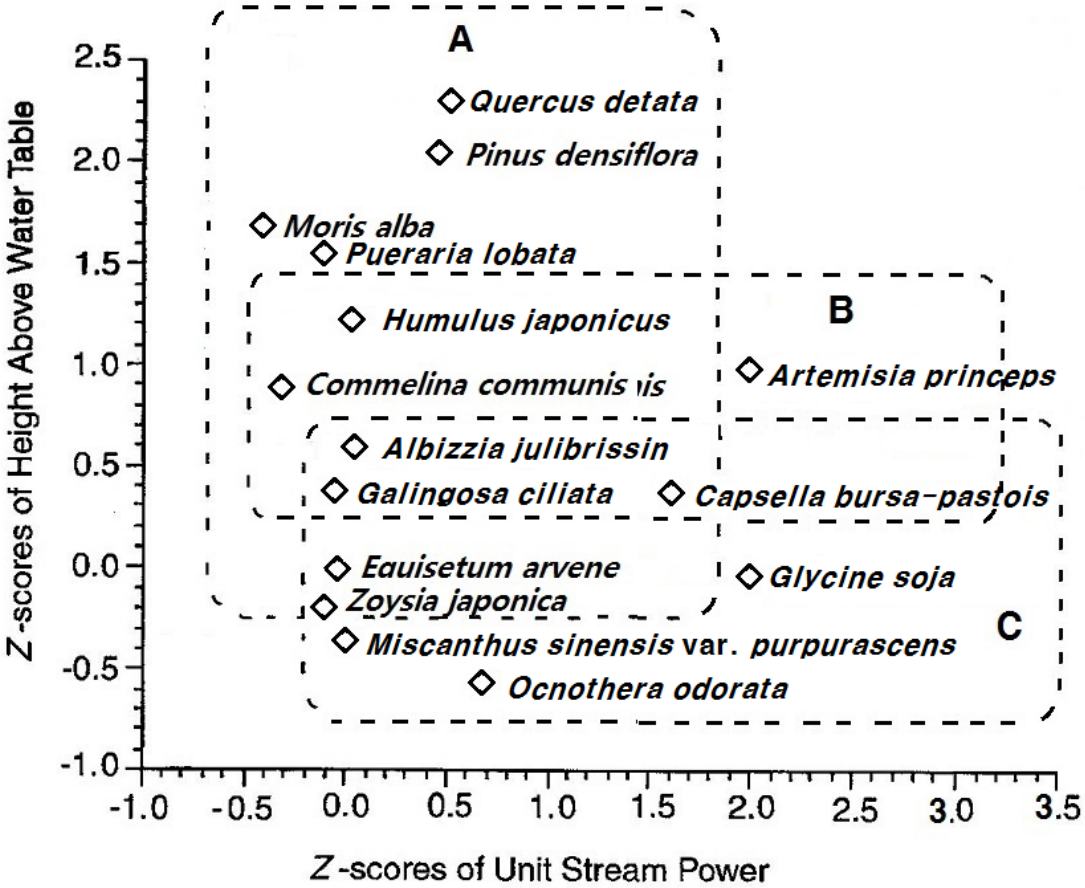

Figure 2. Relationship of 15 common riparian species to unit stream power and height above water table. A, B, and C are regions of Shinjeon River. Modified from Benix and Hupp (2000).

DISCUSSION

The strip of land beside a waterway is a called the riparian zone and it is a crucial buffer between land and water. Riparian buffers are the grasses, grass-like, forbs, shrubs, trees or other vegetation growing along streams. These plants control erosion and help filter and keep water clean. Shrubs, trees and other vegetation protect the stream from pollutants and runoff. They absorb excess nutrients such as nitrogen and phosphorus from farm and livestock operations. The buffer needs to be of an appropriate width depending on slope, flood levels and farming requirements. The riparian buffer zone vegetation can consist of ungrazed grass, commercial trees, stock shelter tree lines, native plants, carefully grazed grass or a combination of these. The variation in species composition could also be related to the effects of environmental factors such as altitude, aspect, soil contents and moisture, human impacts and grazing intensity (Bekele, 1993). In many areas, catchment-scale hydrological modifications and invasive alien plants are among the most influential agents of degradation (Richardson et al., 2007). From 24 most frequent invaders in the natural vegetation were found in the Shinjeon 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). Reservoirs, roads, and urban areas break up the continuity of riparian corridors, one of their critical ecological attributes. The Shinjeon River is also undergoing such changes due to industrialization. Significant changes in biological and spatial composition alter the structure of ecosystems, which in turn influence the processes underlying such ecosystems. A conservation strategy for the riparian vegetation of this river is needed before much destruction has taken place.

REFERENCES

Benix, J., & Hupp, C.R. (2000) Hydrological and geomorphological impacts on riparian plant communities. *Hydrological Processes, 14*, 2977-90.

Bekele, T. (1994) Phytosociology and ecology of a humid Afromontane forest on the central plateau of Ethiopia. *Journal of Vegetation Science*, *5*, 87–98.

Brinson, M.M. (1990) Riverine forests. In: A.E. Lugo, M.M. Brinson & S. Brown (Eds.), *Forested wetlands*. Amsterdam, The Netherlands: Elsevier.

Braun-Blanquet, J. (1964) *Pflanzensoziologie, Grundzüge der Vegetationskunde* (3rd ed). New York: Springer, Wein.

Campbell, A.G., & Fro.nklin, J.F. (1979) *Riparian vegetation in Oregon's western Cascade Mountains: composition, biomass, and autumn phenology, Bull. No, 14, coniferous forest biome, ecosystem analysis studies*. Seattle, WA: University of Washington.

Cox, G. (1990) *Laboratory Manual of General Ecology*, 6th ed., Dubuque, Iowa: William C. Brown.

Dietvorst, P., Maarel, V.D., & van der Putten, H. (1982) A new approach to the minimal area of a plant community. *Vegetario 50*, 77-91.

Goebel, P.C., Palik, B.J., & Pregitzer, K.S. (2003) Plant diversity contributions of riparian areas in watersheds of the northern Lake States, USA. *Ecological Application, 13*, 1595-609.

Gregory, S.V. (1997) Riparian management in the 21st century. In: K.A. Kohm & J.F. Franklin (Eds.), *Creating a forestry for the 21st century: the science of ecosystem management*. Washington, DC, and Covelo, CA: Island Press.

Hill, M.O. (1973) Diversity and evenness: a unifying notation and its consequences. *Ecology, 54*, 423-32.

Kattelmann, R., & Embur, M. (1996) *Riparian areas and wetlands*. University of California, Centers for Water and Wildland Resources.

Kim, J.W. (1996) Floristic characterization of the temperature oak forests in the Korean Peninsula using high-rank taxa. *Journal of Plant Biology, 39*, 149-59.

Korea National Arboretum. (2012) *Field Guide, Naturalized Plants of Korea*. Korea National Arboretum, Seoul, Korea.

Lee, Y.N. (2007) *New Flora of Korea*. Kyo-Hak Publishing Co., Seoul, Korea.

Magurran, A.E. (1988) *Ecological Diversity and its Measurement*. Princeton University Press, Cambridge, USA.

Miiller, N. (1995) River dynamics and floodplain vegetation and their alterations due to human impact. *Archiv fur Hydrobiologie Supplement, 101(9)*, 477-512.

Moon, S.G., & Huh, M.K. (2016) River health and distribution of riparian at the tributary of Hakri River, Hapcheon-gun, Korea. *International Journal of Advanced Multidisciplinary Research, 3*, 45-51.

Naiman, R.J., Décamps, H. & Pollock, M. (1993) The role of riparian area corridors in maintaining regional diversity. *Ecological Application*, *3*, 209-12.

Pielou, E.C. (1966) The measurement of diversity in different types of biological collection. *Journal of Theoretical Biology*, *13*, 131-44.

ISSN 2056-5984

Richardson, D.M., Holmes, P.M., Esler, K.J., Galatowitsch, S.M., Stromberg, J.C., Kirkman, S.P., Pyšek, P., & Hobbs, R.J. (2007) Riparian zones - degradation, alien plant invasions and restoration prospects. *Diversity and Distributions, 13*, 126–39.

Shannon, C.E., & Weaver, W. (1963) *The Measurement Theory of Communication.* Urbana: Univ. of Illinois Press.