FLORISTIC CHARACTERIZATION AND BIODIVERSITY OF RIPARIAN ZONES AT THE GWANGYANG RIVER, KOREA

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ABSTRACT

This study of the vegetation of the Gwangyang River in Korea is examined river naturality and vegetative composition of river riparian zones to identify their most important sources of variation. The river was divided into 3 compartments for convenience. Sampling with quadrats (plots of a standard size) can be used for most plant communities. The upper region was 40 families, 99 genera, 108 species, 6 varieties, and one form have been identified. The value of cover-abundance was total 10.54. A Shannon-Weaver indices (H´) of diversity were varied from 2.305 (trees) to 3.715 (forbs). Naturalized Index(NI) and Urbanization Index(UI) were 9.7% and 3.4%, respectively. The middle region was 25 families, 78 genera, 93 species, 6 varieties, and 3 forms. The total transformed Braun-Blanquet value and r-NCD at upper area were 320 and 3,555.6, respectively. The low region was 18 families, 48 genera, 61 species, 6 varieties, and 3 forms. The total transformed Braun-Blanquet value and relative net contribution degree (r-NCD) at upper area were 260 and 2,888.9, respectively. When Jaccard's Index of Similarity (ISj) were applied to Gwangyang River, the most similar sites were middle and low areas (ISj = 42.6%). Upper and low were the most dissimilar (ISj = 25.5%). Sorensen's Index of Similarity (ISs) was also used because it gives greater weight than Jaccard's to the species that recur in the two test areas than to those that are unique to either area. Upper and low were the most dissimilar (ISs = 28.9%).

Keywords: Braun-Blanquet, Gwangyang River, relative net contribution degree (r-NCD), Shannon-Weaver indices.

INTRODUCTION

On land, precipitation and temperature are the chief determinants of the distribution and abundance of life. In aquatic zones, however, water is abundance and temperature relatively constant (Chiras, 1998). The abundance and diversity of life-forms are determined principally by energy and nutrients. Aquatic zones may be either freshwater or saltwater. In both freshwater and saltwater aquatic life zones, may food chains begin with a group of producer organisms. Streams and rivers are home to a variety of plants. While some freshwater plants are aggressive weeds, others help regulate the delicate ecosystems of streams and rivers by providing food and nourishment to fish and wildlife. One of the primary ways in which humans use water is by planting important crops in places where they can capture natural rainfall as rain-fed agriculture. Some forms of agriculture, such as intensive rice and corn production, can be practiced only in rainy climates. Because agricultural crops are so dependent on water, purposely adding water, beyond what naturally falls as rain, is widely practiced to increase agricultural production. This critical practice is known as irrigation. In most of Asia, rice is not only the staple food, but also constitutes the major economic activity and a key source of employment and income for the rural population. Water is the single most important component for sustainable rice production, especially in the traditional rice growing areas of the Region. The Gwangyang River has provided many critical goods and services, including drinking water, agricultural water for a long time. The stream begins in a forested area and runs through Gwangyang and into the Pacific Ocean. Gwangyang is a city in South JeollaProvince, South Korea. Gwangyang is at the centre of development for the Gwangyang Bay Area Free Economic Zone (GFEZ) due for completion in 2011. The Free Economic Zone will focus on port container handling, steel production, shipbuilding as well as leisure facilities.

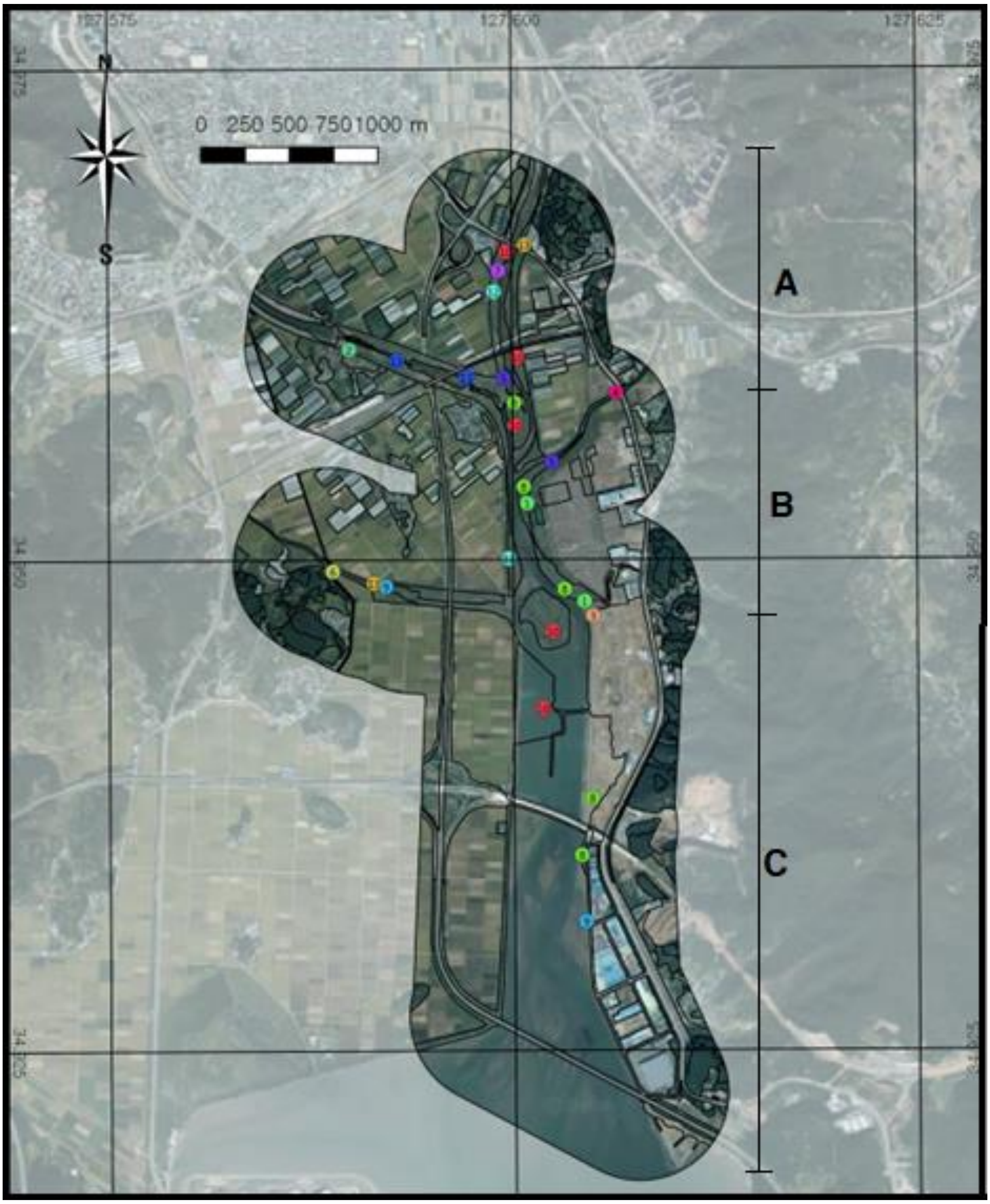
Riparian vegetation is a crucial component of fluvial systems and serves multiple socio-ecological functions (Malanson, 1993; Naiman et al., 2005). Much of the research on riparian vegetation has been directed at relating site history to successional status of vegetation (Bendix and Hupp, 2000). Biologically, riparian vegetation is species-rich and increases regional biodiversity (Sabo et al., 2005). Urbanization is one of the most significant demographic trends of all times (Pickett et al. 2001) and it has a devastating impact on the environment (Wu et al., 2003). The increase in population density of urban areas (Pickett et al., 2001) results in infrastructure development and the subsequent transformation of natural areas (Lubbe et al., 2011).

The objective of this study was to provide flora and species diversity to riparian of Gwangyang River, Gwangyang-ci in Korea, from surveys of three areas. These included (1) upland, forest; (2) middle land riparian; and (3) lowland, riparian/riverbank communities. The results 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 Gwangyang River located at Gwangyang-ci, Jeollanam-do province in Korea (Figure 1). The average yearly temperature at this region is 13.7°C (56.7 F), the average in January is 0.1 °C (32.2°F), and the average in July is 27.8°C (82.0°F). The average yearly precipitation is 1,296 mm (51.02 in).



1: *Forsythia koreana* community, 2: *Trichosanthes kirilowii* var. *japonica*, 3: *Aster hayatae*, 4: *Melia azedarach*, 5: *Phacelurus latifolius*, 6: *Boehmeria nipononivea*, 7: *Carex stipata*, 8: halophytic community, 9: , 10: *Salix chaenomeloides*, 11: *Alisma plantago-aquatica* var. *orientale* , 12: *Ulmus parvifolia*, 13: *Aphananthe aspera*.

Figure 1: Location of the study area at the Gwangyang River and representative species.

Floristic Analysis

Plants were collected to help determine the overall diversity of the county. Sampling with quadrats (plots of a standard size) can be used for most plant communities (Cox, 1990). Abundance and cover degree are usually estimated together in a single combined estimation or

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cover-abundance scale from Braun-Blanquet (1964). 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

Biological data can be complex and difficult to understand for laypeople, so various "biotic indices" have been developed to make them easier to understand.

The Shannon index has been a popular diversity index in the ecological literature (Shannon and Weaver, 1963) and the Shannon entropy quantifies the uncertainty (entropy or degree of surprise) associated with this prediction.

Shannon diversity index (H') is $H' = -\Sigma\, p_i \ln p_i$, where 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).

$N = e^{H'}$

Richness simply quantifies how many different types the dataset of interest contains, 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).

$E = H' / \ln(S)$

Jaccard's Index of Similarity (ISj) was used to assess differences/similarities among the three sites (Hastings and Rothenberger, 2013).

$ISj = \{c/(a+b+c)\}\times 100$

where a is the number of species unique to site #1, b is the number of species unique to site #2, and c is the number of common species. For comparison, it was useful to apply another similarity test, The Sørensen index, also known as Sørensen's similarity coefficient, is a statistic used for comparing the similarity of two samples. It also uses on presence-absence data. Sorensen's Index of Similarity (ISs), $ISs = \{2c/(2c+a+b)\}\times 100$, where c = the number of species common to the two sites, a = the total number of species at a given site and b = the total number of species at the other site in the comparison.

The percent of naturalized plant species, PN) and urbanization index (UI) were calculated the methods of Numata (1975) and Yim and Jeon (1980), respectively.

RESULTS

A region

The upstream area consists of two streams and is merged into one river. The mean stream width at this region is about mean 5.5 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. 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, 40 families, 99 genera, 108 species, 6 varieties, and one form have been identified (Table 1). The dominant species (according to cover and frequency) that occur in the A region are *Trifolium pratense*, *Artemisia princeps*, and *Zoysia japonica*. The dominant vegetation of low water's edge was *Artemisia capillaris.* Dominant species in flood plains was *Zoysia japonica.* Naturalized plants were eleven species. The total transformed Braun-Blanquet value and r-NCD at upper area were 334 and 3,711.1, respectively.

The value of cover-abundance was total 10.54 (Table 2). Cover-abundance values of trees and shrubs were 1.27 and 2.58, respectively. Cover-abundance values of grasses and forbs were 3.63 and 3.05, respectively. A Shannon-Weaver indices (H´) of diversity were varied from 2.305 (trees) to 3.715 (forbs). For the community as a whole, richness of trees was low (3.789). The richness indices were varied from 3.789 (trees) to 10.539 (forbs). The evenness indices were varied from 0.927 (forbs) to 0.969 (grasses). Although diversity (H´) and evenness indices were different from each other, there were not shown significant differences ($p < 0.05$). However, diversity (N) and richness indices were shown significant differences ($p > 0.05$).

When Jaccard's Index of Similarity (ISj) were applied to Gwangyang River, the most similar sites were middle and low areas (ISj = 42.6%) (Table 3). Upper and low were the most dissimilar (ISj = 25.5%). Sorensen's Index of Similarity (ISs) was also used because it gives greater weight than Jaccard's to the species that recur in the two test areas than to those that are unique to either area. Upper and low were the most dissimilar (ISs = 28.9%).

Naturalized Index(NI) and Urbanization Index(UI) were 9.7% and 3.4%, respectively (Table 4).

B region

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, 78 genera, 93 species, 6 varieties, and 3 forms have been identified (Table 1). The dominant species (according to cover and frequency) that occur in the A region are *Trifolium pratense, Plantago asiatica, Artemisia princeps, Phragmites communis,* and *Zoysia japonica*. The dominant vegetation of low water's edge was *Miscanthus sinensis* for. *purpurascens.* Naturalized plants were 22 species. The total transformed Braun-Blanquet value and r-NCD at upper area were 320 and 3,555.6, respectively.

The value of cover-abundance was total 10.45 (Table 2). Cover-abundance values of trees and shrubs were 1.20 and 2.57, respectively. Cover-abundance values of grasses and forbs were 3.46 and 3.21, respectively. A Shannon-Weaver indices (H´) of diversity were varied from 1.561 (trees) to 3.511 (forbs). For the community as a whole, richness of shrubs was low

(2.076). The evenness indices were varied from 0.854 (forbs) to 0.977 (grasses). Diversity (N) and richness indices were shown significant differences ($p > 0.05$).

Naturalized Index(NI) and Urbanization Index(UI) were 21.6% and 6.8%, respectively (Table 4). The value of UI was twice as high as that of the upper stream.

C region

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, 18 families, 48 genera, 61 species, 6 varieties, and 3 forms have been identified (Table 1). The dominant species (according to cover and frequency) that occur in the A region are *Salicornia europaea, Suaeda glauca, Suaeda japonica, Miscanthus sacchariflorus, Phragmites communis,* and *Zoysia japonica*. The dominant vegetation of low water's edge was *Miscanthus sinensis* for. *purpurascens.* Dominant species in flood plains was *Zoysia japonica.* The total transformed Braun-Blanquet value and r-NCD at upper area were 260 and 2,888.9, respectively.

The value of cover-abundance was total 12.46 (Table 2). Cover-abundance values of trees and shrubs were 2.0 and 2.5, respectively. Cover-abundance values of grasses and forbs were 4.37 and 3.60, respectively. A Shannon-Weaver indices (H´) of diversity were varied from 0.562 (trees) to 3.724 (forbs). For the community as a whole, richness of shrubs was low (0.621). The evenness indices were varied from 0.811 (trees) to 0.971 (shrubs). Diversity (N) and richness indices were shown significant differences ($p > 0.05$).

Naturalized Index(NI) and Urbanization Index(UI) were 28.6% and 6.1%, respectively (Table 4). The value of UI was similar to that of the middle stream (6.8).

DISCUSSION

Vegetation has numerous functions in riparian zones and wetlands. It defines the number and type of wildlife habitats present. Both the physical and biological structure of riparian vegetation also has a strong influence on the growth, density and biomass in adjacent streams. Little is known, however, about how individual riparian areas contribute to plant diversity, how fluvial landforms outside of the floodplain contribute, and at what scale these contributions become evident (Geobel et al., 2003). The farmers turned the lands in flood plains beyond river levee into farmland, narrowing the river width. Thus the plant distribution was restricted at upland and middle regions of the Gwangyang River. The downstream areas were restricted in distribution except for salivary plants as seawater flowed in during high tide.

Urbanisation is increasing worldwide and is regarded a major driver of environmental change altering local species assemblages in urban green areas (Melliger et al., 2018). Urbanisation-related factors including reduced habitat size and increased spatial isolation change the dynamics of plant and animal populations in urban green areas (McKinney, 2003). As urbanization progressed, roads were built around the river and paved with cement and asphalt, reducing plant habitats. There were 112 species of plants in the upper regions, 102 species in the middle and 70 species in the lower regions (Table 1). however, naturalized plants have been increased to 11 species upstream, 22 species downstream, and 20 species downstream. The number of trees and shrubs decreased from the upper to the lower regions. Trees were 9.9% in upper-class areas, 4.9% in mid-stream areas and 2.9% in downstream areas (Table 2). Shrubs were 17.0% in upper area, 6.9% in mid-stream areas and 2.9% in downstream areas. The observed changes in species composition in our study should thus translate to changes in bilological diversity and richness (Table 2). A Shannon-Weaver indices (H´) of diversity for trees was 2.305 in upper area, 1.561 in midle and 0.562 in low area. Richness was same treand. These studies indicate that urbanization can decrease species richness, depending on several variables.

As a natural and physical factor in this river, salinity affects the distribution of plants. The inflow of seawater has reduced the plant species and halophytes are distributed from coastal regions to inland. Halophytes on Gwangyang River was and 11 species.

CONCLUSION

The biodiversity at three regions of the Gwangyang River is mainly a result of the combination of upland mixed-shrubs/grass and the riparian/riverbank communities associated with the Family Compositae and Gramineae. Other plant communities of significance are the wooded uplands that extend west-east along the south side of the river, scattered Transversal & longitudial sandbars, and the vegetation that borders small tributaries of the river. The inflow of seawater has reduced the plant species and naturalized plants have increased with urbanization.

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Table 1: List of vascular plants, Braun-Blanquet's score, and r-NCD at three regions of Gwangyang River

Family	Species	Region			Invaded plant	r-NCD		
		Upper	Middle	Low		Upper	Middle	Low
Equisetaceae	*Equisetum arvense* L.	6	3	2		66.7	33.3	22.2
Aspidiaceae	*Dryopteris lacera* (Thunberg) Kuntze	2				22.2		
Salicaceae	*Populus euramericana* Guinier		1				11.1	
	Salix chaenomeloides Kimura		1				11.1	
	Salix koreensis Andersson		1				11.1	
	Salix gracilistyla Miquel	3	2			33.3	22.2	
	Salix pseudo-lasiogyne Leveille		1				11.1	
	Salix subfragilis Anderson	2	2			22.2	22.2	
Juglandaceae	*Juglans mandshurica* Maxim.	2				22.1		
Ulmaceae	*Aphananthe aspera* (Thunb.) Planchon	1	1			11.1	11.1	
	Celtis sinensis Pers.	1				11.1		
	Ulmus parvifolia Jacq.	3				33.3		
	Zelkova serrata (Thunb.) Makino	2				22.2		
Moraceae	*Broussonetia kazinoki* Sieb.		3				33.3	
	Humulus japonicus S. et Z.	6	6	3		66.7	66.7	33.3
	Morus alba L.	2				22.2		
	Morus bombycis Koidz.	1				11.1		
Polygonaceae	*Persicaria hydropoper* (L.) Spach.	3				33.3		
	Persicaria nodosa (Persoon) Opiz	2				22.2		
	Persicaria perfoliata (L.) H. Gross	2				22.2		
	Persicaria thunbergii H. Gross		3	5			33.3	55.6
	Rumex acetosa L.		4	4			44.4	44.4
	Rumex crispus L.	2	4	5		22.2	44.4	55.6
	Rumex japonicus Houttuyn			2				22.2
Chenopodiaceae	*Atriplex gmelinii* C. A. Meyer		3	2			33.3	22.2

	Chenopodium acuminatum Willd.			3				33.3
	Chenopodium album var. *centrorubrum* Makino	2	2	3		22.2	22.2	33.3
	Chenopodium ambrosioides L.		2	2	Nat.		22.2	22.2
	Chenopodium glaucum L.		1	2	Nat.		11.1	22.2
	Kochia scoparia Schrader for. *littorea* Kitam.		2	2			22.2	22.2
	Salicornia europaea L.			9				100.0
	Suaeda glauca (Bunge) Bunge			9				100.0
	Suaeda japonica Makino			9				100.0
Phytolaccaceae	*Phytolacca americana* L.	2			Nat.	22.2		
Caryophyllaceae	*Arenaria serpyllifolia* L.	3	3			33.3	22.2	
	Cerastium holosteoides var. *hallaisanense* Mizushima		3				33.3	
	Dianthus chinensis L.	2	2			22.2	22.2	
	Stellaria aquatica (L.) Scop.	3	3			33.3	33.3	
Ranunculaceae	*Clematis apiifolia* DC.	2	2			22.2	22.2	
Papaveraceae	*Papaver rhoeas* L.		4		Nat.		44.4	
Cruciferae	*Brassica juncea* Czern		2	3	Nat.		22.2	33.3
	Brassica vampestris var. *nippo-oleifera* Makino	2	4	5		22.2	44.4	55.6
	Descurainia sophia (L.) Webb	4	5	3		44.4	55.6	33.3
	Lepidium virginicum L.	3	3	2	Nat.	33.3	33.3	22.2
	Rorippa indica (L.) Hiern		3	4			33.3	44.4
	Thlaspi arvense L.	3	3			33.3	33.3	
Rosaceae	*Duchesnea chrysantha* (Zoll. et Mor.) Miquel	2				22.2		
	Potentilla anemonefolia Lehman	2				22.2		
	Prunus jamasakura Sieb.	1	2	1		11.1	22.2	11.1
	Prunus persica (L.) Batsch	3				33.3		
	Rosa multiflora Thunb.	2		3		22.2		33.3
	Rosa wichuraiana Crep. ex Franch. & Sav.	2				22.2		
	Rubus crataegifolius Bunge	3				33.3		

Leguminosae	*Albizzia julibrissin* Durazz.	1				11.1		
	Amorpha fruticosa L.	3			Nat.	33.3		
	Amphicarpaea trisperma (Miq.) Baker	4				44.4		
	Astragalus sinicus L.		2		Nat.		22.2	
	Glycine soja S. et Z.	3	4			33.3	44.4	
	Kummerowia stipulacea (Maxim.) Makino	4	2			44.4	22.2	
	Kummerowia striata (Thunb.) Schindl.	2	3			22.2	33.3	
	Lespedeza cuneata (Dumont d. Cours.) G. Don	3				33.3		
	Pueraria lobata (Willd.) Ohwi	5	3			55.6	33.3	
	Robinia pseudo-acacia L.	3	2		Nat.	33.3	22.2	
	Trifolium pratense L.	9	9	6		100.0	100.0	66.7
	Trifolium repens L.		2	2	Nat.		22.2	22.2
	Vicia amoena Fischer	3	2			33.3	22.2	
	Vicia angustifolia L.		2				22.2	
	Vicia hirsuta (L.) S. F. Gray	3	3			33.3	33.3	
	Vicia villosa Roth			2	Nat.			22.2
	Vigna angularis var. *nipponensis* Ohwi & Ohashi	2				22.2		
	Wisteria floribunda (Will.) DC.	1				11.1		
Geraniaceae	*Geranium thunbergii* Sieb.et Zucc.	6	5	3		66.7	55.6	33.3
Oxalidaceae	*Oxalis corniculata* L.	2	3	2		22.2	33.3	22.2
Meliaceae	*Melia azedarach* L.	1				11.1		
Euphorbiaceae	*Securinega suffruticosa* (Pallas) Rehder	2				22.2		
Anacardiaceae	*Rhus javanica* L.	2				22.2		
Celastraceae	*Euonymus sieboldianus* Nakai.	1				11.1		
Vitaceae	*Ampelopsis brevipedunculata* (Maxim.) Trautz.	3				33.3		
Cucurbitaceae	*Cucurbita moschata* (Duchesne) Poiret	2	2			22.2	22.2	
	Trichosanthes kirilowii var. *japonica* Kitagawa	2				22.2		
Onagraceae	*Oenothera biennis* L.			2	Nat.			22.2
	Oenothera odorata Jacq.	2	4	3	Nat.	22.2	44.4	33.3

Halorrhagaceae	*Myriophyllum spicatum* L.	2				22.2		
Araliaceae	*Aralia elata* (Miquel) Seemann	2				22.2		
Umbelliferae	*Cnidium monnieri* (L.) Cusson	3				33.3		
	Oenanthe javanica (Bl.) DC.	6	4			66.7	44.4	
Plumbaginaceae	*Limonium tetragonum* (Thunb.) A. A. Bullock		3	3			33.3	33.3
Asclepiadaceae	*Metaplexis japonica* (Thunb.) Makino	2				22.2		
Convolvulaceae	*pomoea purpurea* Roth			2	Nat.			22.2
Polemoniaceae	*Phlox subulata* L.	2				22.2		
Verbenaceae	*Callicarpa dichotoma* (Lour.) K. Koch	1				11.1		
	Clerodendron trichotomum Thunb.	1				11.1		
Labiatae	*Lamium amplexicaule* L.	3				33.3		
	Leonurus japonicus Houttuyn	2				22.2		
Solanaceae	*Solanum carolinense* L.	2	3			22.2	33.3	
Scrophulariaceae	*Paulownia coreana* Uyeki	1	1			11.1	11.1	
	Veronica anagallis-aquatica L.	2	2			22.2	22.2	
	Veronica arvensis L.		4	2	Nat.		44.4	22.2
	Veronica persica Poir		2	3	Nat.		22.2	33.3
Plantaginaceae	*Plantago* asiatica L.	7	9	8		77.8	100.0	88.9
	Plantago camtschatica Chamisso		3	4			33.3	44.4
	Plantago major var. *japonica* for. *yezomaritima* Ohwi		4	5			44.4	55.6
	Plantago virginica L.		2	3	Nat.		22.2	33.3
Compositae	*Artemisia capillaris* Thunb.	8	8	3		88.9	88.9	33.3
	Artemisia fukudo Makino	4				44.4		
	Artemisia princeps Pamp.	9	9	7		100.0	100.0	77.8
	Aster hayatae Leveille et Vaniot	3				33.3		
	Aster tripolium L.		3	3			33.3	33.3
	Bidens bipinnata L.	2	2			22.2	22.2	
	Bidens frondosa L.	2	3	3	Nat.	22.2	33.3	33.3
	Bidens pilosa L.			2	Nat.			22.2

	Coreopsis alternifolia L.		2		Nat.		22.2	
	Coreopsis lanceolata L.		4	3	Nat.		44.4	33.3
	Cosmos bipinnatus Cav.	3	4	2	Nat.	33.3	44.4	22.2
	Erigeron annuus (L.) Pers.	4	5	4	Nat.	44.4	55.6	44.4
	Erigeron canadensis L.	3	3	5	Nat.	33.3	33.3	55.6
	Erigeron sumatrensis E. Walker		2		Nat.		22.2	
	Helianthus annuus L.	3				33.3		
	Helianthus tuberosus L.	2			Nat.	22.2		
	Hemistepta lyrata Bunge	2				22.2		
	Lactuca indica L. var. *laciniata* Hara	2	3			22.2	33.3	
	Petasites japonicus (Sieb. et Zucc.) Maxim.	2				22.2		
	Sonchus asper (L.) Hill	2	2	3	Nat.	22.2	22.2	33.3
	Tagetes minuta L.		2	2			22.2	22.2
	Taraxacum officinale Weber	2	3	3	Nat.	22.2	33.3	33.3
	Taraxacum platycarpum Dahlst.	2	3	2		22.2	33.3	22.2
	Xanthium canadense Mill.		2		Nat.		22.2	
	Youngia sonchifolia (Bunge) Maxim.		3	2			33.3	22.2
Typhaceae	*Typha angustifolia* L.	3				33.3		
Potamogetonaceae	*Potamogeton crispus* L.	2				22.2		
Alismataceae	*Alisma plantago-aquatica* var. *orientale* Samuelsson	2	2			22.2	22.2	
Gramineae	*Agropyron ciliare* (Trin.) Fr.	2	3			22.2	33.3	
	Agropyron *tsukusinense* var. *transiens* Ohwi	2	2	2		22.2	22.2	22.2
	Alopecurus aequalis Sobol.	3	2	3		33.3	22.2	33.3
	Beckmannia syzigachne (Steud.) Fernald	3	2			33.3	22.2	
	Bromus japonicus Thunb.	3	2			33.3	22.2	
	Digitaria ciliaris (Retz.) Koel.	4	3			44.4	33.3	
	Echinochloa crus-galli (L.) Beauv.	4	2			44.4	22.2	
	Hemarthria sibirica (Gondoger) Ohwi	3	2			33.3	22.2	
	Imperata cylindrica var. *koenigii* Durand et Sunitz	3	3			33.3	33.3	

	Schaemum aristatum var. *glaucum* T. Koyama		3	2			33.3	22.2
	Miscanthus sacchariflorus (Maxim.) Bentham	3	5	9		33.3	55.6	100.0
	Miscanthus sinensis for. *purpurascens* Nakai	8	9	4		88.9	100.0	44.4
	Paspalum distichum L.	3	4	5		33.3	44.4	55.6
	Phacelurus latifolius (Steud.) Ohwi		2				22.2	
	Phalaris arundinacea L.	2	4	6		22.2	44.4	66.7
	Phragmites communis Trinius	4	9	9		44.4	100.0	100.0
	Phragmites japonica Steud.	3				33.3		
	Poa annua L.	2	3	2		22.2	33.3	22.2
	Pseudosasa japonica (Sieb. et Zucc.) Makino	4				44.4		
	Puccinellia nipponica Ohwi		2	3			22.2	33.3
	Setaria glauca (L.) Beauv.		2	2			22.2	22.2
	Setaria viridis (L.) Beauv.	7	6	7		77.8	66.7	77.8
	Setaria viridis var. *pachystachys* Makino		2	3			22.2	33.3
	Zizania latifolia Turcz.	3				33.3		
	Zoysia japonica Steud.	9	9	9		100.0	100.0	100.0
	Zoysia sinica Hance		2	3			22.2	33.3
Cyperaceae	*Carex dimorpholepis* Steud.		3				33.3	
	Carex neurocarpa Maxim.		2				22.2	
	Carex scabrifolia Steud.			8				88.9
	Carex stipata Muhl.			2				22.2
	Cyperus iria L.	4	3			44.4	33.3	
	Scirpus tabernaemontani Gmel.	4				44.4		
Commelinaceae	*Commelina communis* L.		2	2			22.2	22.2
Juncaceae	*Juncus effusus* L. var. *decipiens* Buchen.	3				33.3		
Total		114	102	70		3711.1	3555.6	2888.9

NAT: Naturalized plants.

Table 2: Mean cover-abundance of species and diversity indices of Gwangyang River

Growth form	No. species (%)	Mean cover-abundance of species	Diversity (H`)	Diversity (N)	Richness	Evenness
A region						
Trees	11 (9.8)	1.27	2.305	10.020	3.789	0.961
Shrubs	19 (17.0)	2.58	2.839	17.104	4.625	0.964
Grasses	27 (24.1)	3.63	3.190	24.286	5.671	0.969
Forbs	55 (49.1)	3.05	3.715	41.073	10.539	0.927
Total	112 (100.0)	10.54	-	-	-	-
B region						
Trees	6 (4.9)	1.20	1.561	4.762	2.232	0.970
Shrubs	7 (6.9)	2.57	1.773	5.888	2.076	0.911
Grasses	28 (27.4)	3.46	3.254	25.889	5.902	0.977
Forbs	62 (60.8)	3.21	3.511	33.487	11.335	0.854
Total	102 (100)	10.45	-	-	-	-
C region						
Trees	2 (2.9)	2.00	0.562	1.755	0.721	0.811
Shrubs	2 (2.9)	2.50	0.673	1.960	0.621	0.971
Grasses	19 (27.1)	4.37	2.771	15.967	4.073	0.941
Forbs	47 (67.1)	3.60	3.724	41.414	8.967	0.967
Total	70 (100)	12.46	-	-	-	-

A: Upper region, B: Middle, C: low.

Table 3: Index of similarity values comparing the three study regions

Region	Jaccard's (ISj)	Sorensen's (ISs)
A and B	41.2	36.8
A and C	25.5	28.9
B and C	42.6	37.4

A, B, and C are the same as Table 2.

Table 4: Naturalized index (NI) and urbanization index (UI) in the three study regions

Index	Region			Total
	Upper	Middle	Low	
NI(%)	9.7	21.6	28.6	17.0
Ul(%)	3.4	6.8	6.1	8.6