FLORA AND SPECIES DIVERSITY OF RIPARIAN ZONES AT JUNGSEONPO RIVER, SACHEON-CI PROVINCE, KOREA

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ABSTRACT

This study was carried out on Jungseonpo River, located at Sacheon-ci, Gyeongsangnam-do province in Korea. The aim of this study was to analyze the flora and species diversity of this river. Samples with quadrats are taken using a standard sampling unit of some kind. According to the existing phytosociological data, 25 families, 51 genera, 44 species, 6 varieties, and one form have been identified at the upper region. The total transformed Braun-Blanquet value and r-NCD at upper area were 152 and 1,688.9, respectively. Shannon diversity index (H') was varied from 0.65 (trees) to 3.30 (forbs). For the community as a whole, richness of trees was very low (0.91). The value of mean cover-abundance was total 9.6. The middle region was a total of 81 taxa, including 27 families, 64 genera, 74 species, 6 varieties, and one form. The low region was a total of 77 taxa, including 21 families, 58 genera, 72 species, four varieties, and one form. Naturalized plants were 27 species. When Jaccard's Index of Similarity (ISj) were applied to Jungseonpo River, the most similar sites were middle and low areas (ISj = 58.1%). The percent of naturalized plant species and urbanization index were 40.8% and 8.9%, respectively

Keywords: Braun-Blanquet, Jungseonpo River, naturalized plants, Shannon diversity index.

INTRODUCTION

The development of modern industrial society has had a huge impact to both rural and urban and economic development of the world wide, affected South Korea as well. In the traditional self-sufficiency period of rural areas, the agricultural structure has changed for sale. Subsequent changes of the industrial structure also were influenced by a wider fluid system. For example, excessive spraying of chemical fertilizers and pesticides are rampant, affecting the river ecosystem.

In Korea, the national forest area is narrow and the population is large, so it depends heavily on imports and exports. Shifting plants from foreign countries due to import and export are buried in these products. Thus, many of these alien species have become naturalized, surviving in the South Korean landscape without needing to be tended, and some of these naturalized species have become invasive. Invasive alien species are able to survive, reproduce and spread, unaided and sometimes at alarming rates, across the landscape. The invasion of newly colonized areas by alien organisms is a global problem of significant and growing proportions (Kaiser, 1999), which can have serious implications for the environment. The invasion of natural ecosystems by alien plants is a serious environmental problem that threatens the sustainable use of benefits derived from such ecosystems (Wilgen et al., 2001). Most past studies in this field have focussed on the history, ecology and management of invasive alien species, and little work has been done on the economic aspects and consequences of invasions. It is important to know where the species including invasive alien species is distributed.

However, this basic survey is not an urgent issue at the moment, or the labor costs are not spent from the economic point of view because the labor cost is much more than the economic profit is generated. In order to prepare for floods, they are hindering natural rivers, for example, by removing plant habitats such as deltas. From the river's point of view, it does not help but interfere. The ecology of the river refers to the relationships that living organisms have with each other and with their environment – the ecosystem. An ecosystem is the sum of interactions between plants, animals and microorganisms and between them and non-living physical and chemical components in a particular natural environment. They observed rivers only from the standpoint of human convenience, not plants or nature.

Rivers provide many critical goods and services, including drinking water, agricultural water, power generation, nutrient recycling, organic matter retention, and habitat for many plants and animals. For sustainable maintain of healthy riverine ecosystems, it is important to understand ecosystem response variables such as biodiversity, productivity and density of plant communities in rivers and streams. Plants have colonized many habitat types, including systems dominated by water such as rivers and wetlands. Plants living in wetlands must be able to survive both inundation and drying as water levels may fluctuate greatly seasonally. Other plants are adapted to live predominantly beneath the water's surface (submergent), others float on the surface (floating), while others emerge from water with stiff stems holding the plants leaves above the water (emergent).

Jungseonpo River originates from the mountain and flows into the Pacific Ocean. The middle and upper stream of this stream is the agricultural zone. The most floodplains of the river have been converted to agricultural or horticultural fields, housing, restricting the river bed to a small channel. There is a military aerodrome at downstream of the river, which limits access to people and preserves vegetation. The objective of this study was to provide flora and species diversity to riparian of Jungseonpo River, Sacheon-ci, Gyeongsangnam-do province in Korea, from surveys of three areas. These included (1) upland; (2) middle land riparian; and (3) lowland, riparian. 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 Jungseonpo River (upper region: 35°109′593″N/128°116′650″E, low region: 35°081′806″N/128°053′772″E), located at Sacheon-ci, Gyeongsangnam-do province in Korea. Jungseonpo River is 11.5 kilometers in length. The river was divided into 3 compartments for convenience. The upper area of Jungseonpo River, including one reservoir (Durang Reservoir), used to be covered with trees and shrubs.

Floristic Analysis

Samples with quadrats are taken using a standard sampling unit of some kind. The size of the quadrat that is appropriate depends on the layer or type of vegetation being sampled. For example, quadrats for grass or herbs and shrubs or trees consist of 1 mx1m frame and 10mx10m, respectively. Random sampling is also carried out when the area under study is fairly uniform, very large, and or there is limited time available. Three sectors of the riparian vegetation on Jungseonpo 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). The collected data are based on an extensive survey of the existing concern spatial distribution, habitat, as well as several life history traits of the alien plant. The system of plant classification system was followed by Lee (2007). The identification of naturalized plants was 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). 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 was calculated the Shannon diversity index (H') (Shannon and Weaver, 1963) and the important value index of all the species (N) is also calculated. The species richness was calculated by using the method, Margalef's index (R) of richness (Magurran, 1988). Evenness index was calculated using important value index of species (Hill, 1973; Pielou, 1966). Jaccard's Index of Similarity (ISj) was used to assess differences/similarities among the three sites (Hastings & Rothenberger, 2013). For comparison, it was useful to apply another similarity test, The Sørensen index, also known as Sørensen's similarity coefficient (ISs), is a statistic used for comparing the similarity of two samples. The percent of naturalized plant species (NI) and urbanization index (UI) were calculated the methods of Numata (1975) and Yim and Jeon (1980), respectively.

RESULTS

A region

The mean stream width at this region is about 5.0 m. The vegetation of low water's edge was natural weeds, shrubs, and mixed. The application of the Braun-Blanquet approach for plant classification in this area is presented (Table 1). According to the existing phytosociological data, 25 families, 51 genera, 44 species, 6 varieties, and one form have been identified. Naturalized plants were eleven species. The dominant species (according to cover and frequency) that occur in the upper region are *Trifolium repens*, and *Zoysia japonica* which are over 6 for the application of the Braun-Blanquet approach. The total transformed Braun-Blanquet value and r-NCD at upper area were 152 and 1,688.9, respectively.

The value of mean cover-abundance was total 9.6 (Table 2). Cover-abundance values of trees and shrubs were 1.50 and 2.45, respectively. Cover-abundance values of grasses and forbs were 2.79 and 2.86, respectively. Shannon diversity index (H') was varied from 0.65 (trees) to 3.30 (forbs). For the community as a whole, richness of trees was very low (0.91). The total richness indices were varied from 3.03 (shrubs) to 6.34 (forbs). The evenness indices were varied from 0.883 (shrubs) to 0.979 (forbs). Although evenness indices were different from each other, there were not shown significant differences ($p < 0.05$). Naturalized Index (NI) and Urbanization Index (UI) were 20.0% and 2.5%, respectively (Table 4).

B region

The mean river width at the region is about 32.5 m. Riverbed area was dominated by the distribution of three willow species (*Salix chaenomeloides*, *Salix gracilistyla*, and *Salix koriyanagi*) (Table 1). The dominant vegetation of low water's edge was Polygonaceae (eight species including *Persicaria hydropoper* and two Gramineae (*Miscanthus sinensis* for. *purpurascens* and *Phragmites communis*). The dominant species of left and right riparian areas was Compositae vegetation. The survey region was a total of 81 taxa, including 27 families, 64 genera, 74 species, 6 varieties, and one form. Naturalized plants were 22 species. The total transformed Braun-Blanquet value and r-NCD at middle area were 260 and 2,858.8, respectively. The value of cover-abundance was total 10.55 (Table 2). H´ values were varied from 1.04 (trees) to 3.78 (forbs). The total richness indices were varied from 1.44 (trees) to 9.51 (forbs). The evenness indices were varied from 0.939 (grasses) 0.983 (forbs). Although evenness indices were different from each other, there were not shown significant differences ($p < 0.05$). NI and UI were 37.3% and 6.8%, respectively (Table 4).

C region

The mean river width at the region was about 110.0 m. The dominant species of low water's edge was Gramineae vegetation (*Miscanthus sinensis* for. *purpurascens* and *Phragmites communis*) (Table 1). The dominant vegetation of riverbed area was Polygonaceae (*Persicaria orientalis*). The dominant species of left and right riparian areas was six Rumex species. The survey region was a total of 77 taxa, including 21 families, 58 genera, 72 species, four varieties, and one form. Naturalized plants were 27 species. The total transformed Braun-Blanquet value and r-NCD at middle area were 256 and 2,844.4, respectively. The value of cover-abundance was total 12.0 (Table 2). H´ value was different across growth forms, varying from 0.64 (trees) to 3.87 (forbs). The total richness indices were varied from 0.87 (shrubs) to 10.58 (forbs). The evenness indices were varied from 0.918 (trees and forbs) 0.960 (shrubs). NI and UI were 49.1% and 8.3%, respectively (Table 4).

When Jaccard's Index of Similarity (ISj) were applied to Jungseonpo River, the most similar sites were middle and low areas (ISj = 58.1%) (Table 3). ISj value of the two riparian sites (upper and middle areas) which = 27.3%. Upper and low were the most dissimilar (ISj = 23.1%). Sorensen's Index of Similarity 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. The ISs indices were varied from 27.3% (upper and low) to 42.3% (middle and low). NI and UI were 40.8% and 8.9%, respectively (Table 4).

DISCUSSION

Riparian zones and wetlands provide some of the most important wildlife habitat in Korea. Wildlife use is generally greater than in other habitats because the major life requirements for many species are present (Oakley et al., 1985). Aquatic and riparian regions are the habitat for aquatic life forms, including many species of invertebrates, fish, amphibians, reptiles, birds, and mammals. Vertebrates that either feed or reproduce in water are directly dependent on wetlands or riparian areas and adjacent aquatic areas. Many other species, although not completely dependent on riparian or wetland habitats, tend to use them to a greater degree than upland areas. Although many researchers believe that the contribution of riparian areas to plant diversity often exceeds the proportion of the landscape they occupy (Brinson & Verhoeven, 1999; Ferreira & Stohlgren, 1999; Crow et al., 2000), riparian zones have a greater diversity of plant composition and structure than uplands (Goebel et al., 2003). The willow was not rigid and was unsuitable for wood. Thus, willow in the river was mainly used for chopsticks and firewood. Plastics and gas heating have not plant willow trees in the levee or banks. Except for the trees, because the trees are difficult to grow except the willow species in the river, H´ values were varied from 1.06 (shrubs for low region) to 3.87 (forbs for low region) (Table 3). Korean plant species include 4726 species including 326 naturalized plants.

Naturalized Index (NI) and Urbanization Index (UI) were 40.8% and 8.9%, respectively (Table 4). This result indicated that NI of the study area was higher than the Korean average of NI (6.9%). Although these invasive species do provide some benefits, all of these examples have also come at the cost of decreases in native diversity, often far beyond the boundaries of the original plantings (Mack et al. 2000). In the case of novel systems, invasive species may not be disrupting ecological processes but may be sustaining or restoring ecosystem services under a shifting environment (Hobbs et al., 2009).

REFERENCES

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

Brinson, M.M., & Verhoeven, J. (1999) Riparian forests. In M.L. Hunter, Jr. (Ed.), *Maintaining biodiversity in forest ecosystems*. Cambridge: Cambridge University Press.

Crow, T.R., Baker, M.E., & Barnes, B.V. (2000) Diversity in riparian landscapes. In E.S. Verry, J.W. Hornbeck, & C.A. Dolloff (Eds.), *Riparian management in forests of the Continental eastern United States*. Boca Raton, Florida: Lewi Press, CRC Publishers,

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.

Ferreira, L.V., & Stohlgren, T.J. (1999) Effects of rive] level fluctuation on plant species richness, diversity, and distribution in a floodplain forest in Central Amazonia. *Oecologia, 120,* 582-7.

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.

Hastings, N.D., & Rothenberger, S.J. (2013) A floristic analysis and comparison of plant com munities in Harlan County, Nebraska. *Transactions of the Nebraska Academy of Scien ces 33,* 25-34.

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

Hobbs, R.J., Higgs, E., & Harris, J.A. (2009) Novel ecosystems: implications for conservation and restoration. *Trends Ecology Evolution, 24,* 599–605.

Kaiser, J. (1999) Stemming the tide of invasive species. *Science, 285*, 1836–41.

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

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

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

Mack, R.N. et al. (2000) Biotic invasions: causes, epidemiology, global consequences, and control. *Ecological Applications, 3,* 689–710.

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

Numata, M. (1975) *Naturalized Plants*. Tokyo: Dai Nippon printing Co.

Oakley, A.L. et al. (1985) Riparian zones and freshwater wetlands. In: E.R. Brown (Ed.), Management *of wildlife and fish habitats in forests of western Oregon and Washington.*

ISSN 2056-5860

Part 1–Chapter narratives. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region.

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

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

van Wilgen, V.W. et a. (2001) The economic consequences of alien plant invasions: examples of impacts and approaches to sustainable management in South Africa. Environment, Development and Sustainability, 3, 145-68.

Westfall, R.H. (1992) Objectivity in stratification, sampling and classification of vegetation Ph.D. thesis. University of Pretoria, Pretoria.

Yim, Y.J., & Jeon, E.S. (1980) Distribution of naturalized plants in the Korean peninsula. *Korean Journal of Botany, 23*, 69-83.

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

Family	Species	Region			Invaded plant	r-NCD		
		Upper	Middle	Low		Upper	Middle	Low
Equisetaceae	*Equisetum arvense* L.		2	4			22.2	
Salicaceae	*Salix chaenomeloides* Kimura		1				11.1	
	Salix koreensis Andersson		1	1			11.1	11.1
	Salix subfragilis Anderson	2	3	3		22.2	33.3	22.2
Juglandaceae	*Juglans mandshurica* Maxim.	1				11.1		
Ulmaceae	*Ulmus parvifolia* Jacq.	2	3			22.2	33.3	
Moraceae	*Humulus japonicus* S. et Z.	3	4	4		33.3	44.4	44.4
	Morus alba L.		2				22.2	
	Morus bombycis Koidz.	2				22.2		
Polygonaceae	*Persicaria hydropoper* (L.) Spach.	4	5	3		44.4	55.6	33.3
	Persicaria orientalis Spach		4	5			44.4	55.6
	Persicaria perfoliata (L.) H. Gross	2				22.2		
	Persicaria senticosa (Meisn.) H. Gross	2				22.2		
	Persicaria thunbergii H. Gross	5	6	5		55.6	66.7	55.6
	Rumex acetosa L.	5	6	6		55.6	66.7	66.7
	Rumex acetoscella L.	3	4	3		33.3	44.4	33.3
	Rumex conglomeratus Murr.		4	5			44.4	55.6
	Rumex crispus L.		4	4			44.4	44.4
	Rumex nipponicus Fr. et Sav.		3	4			33.3	44.4
Chenopodiaceae	*Chenopodium album* L.		3	3			33.3	33.3
	Chenopodium album var. *centrorubrum* Makino	2	4	4		22.2	44.4	44.4
	Suaeda glauca (Bunge) Bunge			3				33.3
	Suaeda maritima (L.) Dumort.			5				55.6

Amaranthaceae	*Achyranthes japonica* (Miquel) Nakai	3	3	2		33.3	33.3	22.2
Caryophyllaceae	*Arenaria serpyllifolia* L.	2	2	1		22.2	22.2	11.1
	Cerastium glomeratum Thuill		3	3			33.3	33.3
	Stellaria aquatica (L.) Scop.	4	5			44.4	55.6	
	Stellaria media (L.) Villars	4	3			44.4	33.3	
Ranunculaceae	*Clematis apiifolia* DC.	2				22.2		
	Ranunculus japonica Thunb.		3	3			33.3	33.3
Papaveraceae	*Chelidonium majus* var. *asiaticum* Ohwi	2				22.2		
Brassicaceae	*Brassica juncea* Czern			3				33.3
	Brassica vampestris var. *nippo-oleifera* Makino		3	5			33.3	55.6
	Capsella bursa-pastoris (L.) Medicus	2	3	3		22.2	33.3	33.3
	Draba nemorosa L.			2				22.2
	Lepidium virginicum L.		3	3			33.3	33.3
	Thlaspi arvense L.		3	3			33.3	33.3
Rosaceae	*Duchesnea chrysantha* (Zoll. et Mor.) Miquel	2				22.2		
	Rosa multiflora Thunb.	2	2			22.2	22.2	
	Rosa wichuraiana Crep. ex Franch. & Sav.	3	2			33.3	22.2	
Leguminosae	*Albizzia julibrissin* Durazz.		4	2			44.4	22.2
	Amorpha fruticosa L.		3	4			33.3	44.4
	Astragalus sinicus L.			4				4.4
	Glycine soja S. et Z.	3	4			33.3	44.4	
	Kummerowia striata (Thunb.) Schindl.		5	7			55.6	77.8
	Medicago minima Bartal.			4				44.4
	Pueraria lobata (Willd.) Ohwi	5				55.6		
	Robinia pseudo-acacia L.	2				22.2		
	Trifolium pratense L.			2				22.2

	Trifolium repens L.	6	7	7		66.7	77.8	77.8
	Vicia amoena Fischer			5				55.6
	Vicia angustifolia L.			3				33.3
	Vicia hirsuta (L.) S. F. Gray		2				22.2	
	Vicia tetrasperma (L.) Moench		3				33.3	
Geraniaceae	*Geranium carolinianum* L.		2	3			22.2	33.3
	Geranium thunbergii Sieb.et Zucc.		2	2			22.2	22.2
Oxalidaceae	*Oxalis corniculata* L.	2	2	2		22.2	22.2	22.2
	Oxalis stricta L.			2				22.2
Simaroubaceae	*Ailanthus altissima* (Mill.) Swingle	1				11.1		
Celastraceae	*Euonymus japonicus* Thunb.	4				44.4		
Aceraceae	*Acer palmatum* Thunb.	1	1			11.1	11.1	
Violaceae	*Viola patrinii* DC.	2				22.2		
Cucurbitaceae	*Cucurbita moschata* (Duchesne) Poiret		2				22.2	
Onagraceae	*Oenothera odorata* Jacq.		4	5			44.5	55.6
Araliaceae	*Aralia elata* (Miquel) Seemann	2	2			22.2	22.2	
Umbelliferae	*Oenanthe javanica* (Bl.) DC.		3				33.3	
Plumbaginaceae	*Limonium tetragonum* (Thunb.) A. A. Bullock			2				22.2
Apocynaceae	*Nerium indicum* Mill.			2				22.2
Convolvulaceae	*Ipomoea triloba* L.		2	3			22.2	33.3
Borraginaceae	*Trigonotis peduncularis* (Trevir.) Bentham		2				22.2	
Labiatae	*Lamium amplexicaule* L.		3	3			33.3	33.3
	Leonurus japonicus Houttuyn	2				22.2		
	Mosla punctulata (J. E. Gmel.) Nakai	3	3			33.3	33.3	
Scrophulariaceae	*Veronica arvensis* L.		2				22.2	
	Veronica persica Poir			2				22.2

Plantaginaceae	*Plantago* asiatica L.	4	5	4		44.4	55.6	44.4
	Plantago camtschatica Chamisso			2				22.2
	Plantago lanceolata L.			2				22.2
Rubiaceae	*Paederia scandens* (Lour.) Merrill	2				22.2		
Compositae	*Artemisia princeps* Pamp.	4	4	5		44.4	4.4	55.6
	Artemisia selengensis Turcz.			2				22.2
	Bidens bipinnata L.		2				22.2	
	Bidens frondosa L.		2	2			22.2	22.2
	Coreopsis lanceolata L.			2				22.2
	Cosmos bipinnatus Cav.	2	3	2		22.2	33.3	22.2
	Erigeron annuus (L.) Pers.	3	4	4		33.3	44.4	44.4
	Erigeron canadensis L.		4	4			44.4	44.4
	Galinsoga ciliata (Raf.) Blake		3	3			33.3	33.3
	Kalimeris yomena Kitamura		2	2			22.2	22.2
	Lactuca indica L. var. *laciniata* Hara		2	2			22.2	22.2
	Petasites japonicus (Sieb. et Zucc.) Maxim.	2				22.2		
	Sonchus asper (L.) Hill		2	2			22.2	22.2
	Taraxacum officinale Weber	2	2	2		22.2	22.2	22.2
	Taraxacum platycarpum Dahlst.	2	2			22.2	22.2	
	Xanthium strumarium L.		2	2			22.2	22.2
Typhaceae	*Typha angustifolia* L.			2				22.2
Gramineae	Agropyron *tsukusinense* var. *transiens* Ohwi		2				22.2	
	Agrostis clavata Trin.		3	3			33.3	33.3
	Alopecurus pratensis L.		2	2			22.2	22.2
	Arthraxon hispidus (Thunb.) Makino		2	2			22.2	22.2
	Beckmannia syzigachne (Steud.) Fernald	2	4	3		22.2	44.4	33.3

	Bromus japonicus Thunb.	3	4	1				
	Digitaria ciliaris (Retz.) Koel.	2	3	3		22.2	33.3	33.3
	Echinochloa crus-galli (L.) Beauv.	2	2	3		22.2	22.2	33.3
	Echinochloa crus-galli var. *frumentacea* Wight	1	2	2		11.1	22.2	22.2
	Festuca arundinacea Schreb.	2	2			22.2	22.2	
	Imperata cylindrica var. *koenigii* Durand et Sunitz		2	2			22.2	22.2
	Miscanthus sacchariflorus (Maxim.) Bentham		3	3			33.3	33.3
	Miscanthus sinensis for. *purpurascens* Nakai	3	9	9		33.3	100	100
	Phalaris arundinacea L.		4	5			44.4	55.6
	Phragmites communis Trinius		9	9			100	100
	Phragmites japonica Steud.	3				33.3		
	Phyllostachys bambusoides Sieb. et Zucc.	3				33.3		
	Phyllostachys nigra Munro var. *henonis* Stapf	4				44.4		
	Poa sphondylodes Trin.	1				11.1		
	Setaria viridis (L.) Beauv.	4	5	4		44.4	55.6	44.4
	Zoysia japonica Steud.	7	9	8		33.3	44.4	100.0
Cyperaceae	*Carex neurocarpa* Maxim.	2						
Commelinaceae	*Commelina communis* L.		2				22.2	
Total		152	260	256		1688.9	2858.8	2844.4

NAT: Naturalized plants.

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

Growth form	No. species (%)	Mean cover-abundance of species	Diversity (H`)	Diversity (N)	Richness	Evenness
A region						
Trees	2 (3.6)	1.50	0.65	1.89	0.91	0.918
Shrubs	11 (19.6)	2.45	2.12	8.32	3.03	0.883
Grasses	14 (25.0)	2.79	2.51	12.36	3.55	0.953
Forbs	29 (51.8)	2.86	3.30	26.99	6.34	0.979
Total	56 (100.0)	9.60	-	-	-	-
B region						
Trees	3 (3.7)	1.33	1.04	2.83	1.44	0.946
Shrubs	10 (12.3)	2.30	2.22	9.24	2.87	0.966
Grasses	19 (23.5)	3.74	2.76	15.87	4.22	0.939
Forbs	49 (60.5)	3.19	3.78	45.85	9.51	0.983
Total	81 (100)	10.55	-	-	-	-
C region						
Trees	2 (2.6)	1.50	0.64	1.89	0.91	0.918
Shrubs	3 (3.9)	3.33	1.06	2.87	0.87	0.960
Grasses	16 (20.8)	3.94	2.60	13.44	3.62	0.937
Forbs	52 (72.7)	3.23	3.87	40.28	10.58	0.918
Total	77 (100)	12.00	-	-	-	-

A: Upper, 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	35.6	34.5
A and C	23.1	27.3
B and C	58.0	42.3

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(%)	20.0	37.3	49.1	40.8
Ul(%)	2.5	6.8	8.3	8.9